# Engineering Checklist for Public School Facilities

***structural***

***plumbing***

***hvac***

***electrical***

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Public Schools of North Carolina
State Board of Education
Department of Public Instruction

Division of School Support · School Planning
Mail Service Center 6319, Raleigh, NC 27699-6319
www.schoolclearinghouse.org

# ENGINEERING CHECKLIST

# FOR

# PUBLIC SCHOOL FACILITIES

# Foreword

Educators, members of the community, and design professionals alike are aware of the impact of physical environment on teaching and learning. School facilities that foster the safest and most productive learning environments while affording long-term efficiency and value challenge the creativity and sensibility of all involved in the facilities-planning process. Engineering components that provide optimum short- and long-term infrastructure are basic to designs that create desirable school facilities.

This publication enumerates recommended minimum engineering guidelines for public school facilities design and is a supplement to the State Board of Education's Public Schools of North Carolina Facilities Guidelines. We hope you find this information useful.

William W. Cobey, Jr., Chairman
State Board of Education

June St. Clair Atkinson, State Superintendent
NC Department of Public Instruction

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## Introduction

Designing school facilities that productively address current and emerging requirements for teaching and learning environments, safety, functional organization and management, and present and long-term value and economy of operation challenges the design professional as perhaps no other undertaking.  Since, over time, quality of both structure and infrastructure will determine the ultimate success of a design, incorporation of the best available engineering components into the planning process is prudent.

This publication identifies a variety of items of interest to engineers, architects, and educators engaged in the development of plans for public school facilities.  Content covers major engineering elements, represents the thinking of a cross-section of design professionals, and is consistent with the *North Carolina Public Schools Facilities Guidelines*.  Included are code items, principles that experience has shown to be desirable and practical, and best practices from a variety of sources.  This *Checklist* serves as a resource for purposes of the mandated State Board plan review and comment process conducted by School Planning.  Review comments must be considered by local boards of education in reviewing plans for proposed construction.

## Using the Checklist

This publication is intended as a reference document for designers of public school facilities.  It is neither comprehensive nor all-inclusive, but provides a guide to pertinent engineering elements for use in plan development.  Content in no way supersedes state or local codes or regulations; federal or state legislation regarding building design and construction, access, or safety; or other legal mandates.

The *Checklist* is organized into four major engineering categories— structural, plumbing, mechanical, and electrical.  Additional notes and related information are placed appropriately, as needed.

Throughout the document, the term *shall* indicate items that are mandatory because of law, code, or regulation.  *Should* indicate items that are standard practice or that experience has shown to be desirable.  Questions regarding checklist items may be addressed to School Planning staff at the address shown on the front cover or by phone at (919) 807-3554.

# Structural

## General

One serious mistake a design professional can make during the preliminary design phase is leaving consideration of the structural system until after the architectural design is finalized. The following guidelines are provided to assist in the provision of adequate structural designs for public school facilities.

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## Related General Statutes

Owners and designers are encouraged to review North Carolina General Statute Chapter 133 to confirm requirements for the use of architects and engineers, preparation of drawings by other parties, consequences of violation of this article and use of energy savings contracts.

## Design and Detailing

Major structural elements, such as columns, beams, trusses, retaining walls, lateral braces, moment frames, shear walls, structural floors, roof decks, footings, and piers should be designed and detailed adequately for varying conditions. Minor structural elements, such as slabs on grade, low retaining walls, lintels and exterior wall and wall openings often get little or no design and are inadequately detailed. Building expansion joints should be designed and provided at proper locations. The engineer representing the owner should include complete details on the drawings to ensure that the contractor knows what is intended.

## Specifications

Inadequate specifications generally fall into one of two categories—incomplete and unrealistic.

Incomplete specifications fail to spell out requirements adequately. An example is failure to require air entrainment in concrete that will be exposed to freezing and thawing. Another form of incomplete specification is stating, "Concrete work shall conform to the requirements of AC1301." Such a requirement is good, but without listing all the supplemental requirements, it is incomplete.

Unrealistic specifications include those that call for tolerances either closer or greater than are really needed and those that require strengths too low to ensure proper performance.  Overly-strict specifications can increase initial costs needlessly, while those that are not strict enough can result in long-term maintenance and repair costs that exceed initial savings.

## Inspection and Control

Effective construction administration by the engineer not only helps the owner get what has been specified, but helps the contractor avoid mistakes.  The competent engineer understands which items are important and the need to be present at critical time during a project, and doesn't waste time nit-picking items that have no bearing on project quality.  Instead, direction is provided to the adjustment or correction of significant out-of-specification materials and procedures.

An excellent way to minimize future repair costs is to take steps to assure the desired quality as the structure is built, beginning with the design detailing of the project and continuing through field inspection and control. Quality control of sensitive aspects of the construction procedure should be considered and emphasized.

### Acceptance of Structural Members

Structural members delivered to the field that are not manufactured in accordance with the plans and specifications and with code standards, should be rejected.  Field modifications to any structural member should not be permitted.  Damaged members should not be used and should be returned.

### Soil / Subsurface Investigation

The nature of the soils underlying a building has a very important influence in determining the type and size of the building's foundation.  As a result, construction costs are significantly affected by the types of soil on which the building is to be built. Foundation type and size affect construction time for the foundation and may therefore have a significant effect on the construction schedule for the entire building.  Because of the pervasive influence of soils on building design and construction, it is highly desirable before a site is purchased that at least some knowledge of the subsurface and surface conditions be obtained and interpreted for the owner by a competent soil engineer.

### Wind Loads

- Calculations of wind loads shall be based on the provisions of NC State Building Code and ASCE 7.

- To determine the wind pressure on a structure, consider the following:

    - Main wind-force-resisting system: At least two directions (sets) of wind loads need to be calculated—one parallel to ridge and one normal to ridge.

- One set force for components and cladding at different zones, regardless of wind direction.
- Internal positive and negative pressures.

- Components and cladding: Structural elements that either are directly loaded by the wind or receive wind loads originating at relatively close locations and that transfer those loads to the main wind force-resisting system.  Examples include curtain walls, exterior glass windows and panels, doors, roof sheathing, purlins, girts, studs, rafters, and roof trusses.

- Main wind-force-resisting system: An assemblage of major structural elements assigned to provide support for secondary members and cladding.  The system receives wind loads primarily from relatively remote locations.  Examples include rigid and braced frames, space trusses, roof and floor diaphragms, shear walls, and rod-braced frames.

## Foundations

- A foundation design should be based on a subsurface investigation report.

- Avoid designing two or more foundation systems for the same building to prevent differential settlement.

- It is advisable to assign fill control testing and inspection work to the same geotechnical firm responsible for the subsurface investigation and recommendations.

- The subsurface investigation report should be included in the specifications.

- Always place the bottom of the footing below the frost line.

- Lower column footings at roof drain leaders.

- Specify drainage fill and drainage tile behind basement walls and retaining walls.

- The bottom of a footing for a new wall or column should at least match the elevation of the bottom of existing wall or column footings.  In most cases, soil around existing footings is loose backfill.

- In order to reduce the possibility of foundation bearing failure and excessive settlement due to local shear or punching action, the North Carolina Building Code requires that footing have a minimum width of 16 inches. Footings should be embedded deep enough below exterior grades to reduce potential movement from frost action or excessive drying shrinkage. For this region, we recommend the bottom of footings be placed at least 18 inches below finished grade.

- Exposure to the environment (especially when bearing soils encounter rainfall or snowfall while exposed) may weaken the soil at footing bearing level if the foundation excavations remain open for too long a time. Foundation concrete should be placed the same day the foundation is excavated.

## Slabs on Grade

- Typical slab-on-grade construction will comprise of a four-inch to five-inch (4-5”) thick concrete slab with adequate welded-wire fabric (W.W.F.) on a four-inch (4”) washed gravel or a 2” sand base on vapor barrier.

- Steel reinforcement should be placed on supports one-third the depth from the top of the slab or to provide a minimum of two inches (2”) of concrete cover.

- There is no equivalent substitute for steel reinforcement in a slab. Steel can reduce random cracking; reduce and control crack width and help to maintain aggregate interlock; prevent the slab from settling or displacing; increase strength and provide reserve strength subsequent to cracking; and provide cost savings over the life of the slab.

- While admixtures, such as fibermix, that can reduce the formation of plastic shrinkage cracks and provide greater impact resistance in a slab may be used along with steel reinforcement, they should not be considered a substitute for steel reinforcement.

- Floor slab joint controls should be provided at a maximum of thirty feet (30’) in any direction. The area within control joints should be as square as possible. Joints should also be provided at columns and wall junctures.

## Floor Construction

- Typical suspended structural floor construction comprises a five-and-one-half inch (5 ½”) total slab thickness with a two-inch (2”), 20-gage composite metal deck, and a span of approximately eight feet (8’-0”) o.c. on steel beams.

- Check the following items for composite beams with formed steel deck:

    - Slab thickness above deck (minimum of 2”)

    - Shear connectors (maximum diameter: ¾”; minimum length after welding: 1 ½” above rib)

    - End reactions must be calculated and shown on the drawings

    - Shoring requirements.

## Roof Construction

- In general, the roof deck serves two primary functions—structurally to transfer the live and dead loads to supporting beams, joists, and purlins and the lateral forces to the vertical structural bracing members; and, to serve as a base to which the roof insulation and membrane are attached.

- Typical structural roof decks used for schools include:

  - Steel: 1 ½" narrow, intermediate, or wide rib (22 gage min.)

  - Tongue-and-groove wood plank or structural plywood/OSB sheathing

  - Lightweight insulating concrete decks and fills (cementitious)

  - Standing-seam metal roofing with 1 ½" structural sub-deck

- The type of roof deck and roof deck anchorage system should be specified.

- Use the diaphragm capacities of a roof deck to transfer lateral force; otherwise, a structural mechanism, such as horizontal trusses, should be employed to transfer lateral forces to designated vertical structural bracing members.

- When a standing-seam roof system is specified, employ a structural roof deck with adequate diaphragm capacity to go with it.

- Specify roof deck anchorage appropriate for the wind zone.

- Lifting and peeling: When perimeter flashing assemblies are inadequately secured, wind uplift forces can remove them and leave the edges of the roof unprotected. Covering, unless well secured, may then be peeled back from the edge and fail. Wind pushing against the covering will cause more of the material to be peeled off, moving the failure inward. In high wind areas, at the perimeter of the roof and at expansion joints, the following are recommended:

  - Attach the "2x" wood plates to the structural members with bolts.

  - In addition to mechanical fasteners, glue the membrane to the wood plate.

  - Secure flashing assemblies at a maximum of from 4" to 6" o.c.

  - Construct a perimeter parapet wall.

  - 18 gage roof decks shall be used at or near coastal regions.

- Whenever possible and practical, the slope required for roof drainage should be incorporated into the structure to effect initial and replacement cost savings.

- Roof slope to drains should be at least ¼” per foot.  There should be no standing water on a roof deck 48 hours after it ceases raining.

- When computing slope, consider deflection under live and dead loads.

- Roofs work best when their geometry is simple.  Any interruption of the roof’s continuity, such as clerestories, roof monitor / skylights, multiple hips, valleys, and wall and expansion joint flashings will complicate roof structure and can lead to leaks and higher maintenance costs.

- Any proprietary roof or building system shall be bid as an alternate to a non-proprietary base bid system (G.S.133-3).

- Roof deck capacities should be specified that support loads required by code, plus an additional 10 psf to cover possible future increases in dead load.  A minimum 22-gage thickness with a maximum five-foot (5’) span is recommended.

- Pull-out tests for mechanical fasteners are required on concrete and cementitious filled decks.

- Consider the following when using cement fiber roof decks:

    - End joints must occur above supports unless bulb tees are specified.

    - The diaphragm action of the deck

    - Joints must be tight.

- Provide 2”x4” treated wood at each rib under curb for roof mechanical unit setting on a metal deck.

- When using a composite metal roof deck system, be aware of the composite action between separate materials and provide a positive nailable material.

- Should a complete removal of roofing material from a composite metal deck include replacement of some of the metal decking, replacement decking should be of the same material to prevent structural deficiencies.

- Avoid specifying loose-laid ballasted (gravel size of ¾” to 1 ½”) roofing systems at or near high-wind locations.  Rocks can become destructive missiles in high winds.

- Roof expansion joints should always be provided at the following locations:

    - Where expansion or contraction joints are provided in the structural system

- Where steel framing, structural steel, or decking change directions
- Where discontinuity in a structural deck occurs
- Where deck type changes (e.g. where a plywood deck and a steel deck abut)
- At junctions where interior heating conditions change, such as a heated office abutting an unheated warehouse.
- Where movement might occur between vertical walls and the roof deck

- Expansion joints may be ineffective where they are not continued through the remainder of the structure.

- Expansion joints and area dividers should be elevated a minimum of eight inches (8") above the plane of waterproofing membrane.

- Roof collapses can occur due to rain or wet snow loading on flat roofs with slopes of 1% or less, roofs of lightweight construction, and roofs designed for minimum live loads. Collapse may also occur with rain overloading caused by inadequate interior drains or perimeter scuppers, rainfall intensities that exceed design expectance, clogged drainage devices, and backed-up storm drainage systems. Roof scupper height should be specified to ensure that no more than six inches (6") of water can accumulate at the drain inlet level, should the drain fail to work.

- The weight of drifting snow is critical to the design of a new roof to reduce its collapse potential and in estimating the collapse potential of an existing roof. Three common roof shapes—multi-level, curved, and valley—are subject to snow drift build-up. One cubic foot of snow can weigh about 14 pounds and wet snow can weigh about 21 pounds per cubic foot.

## Steel Joists

- Manufacturers' calculations for load-carrying capacities of joists consider only the uniformly distributed vertical loads in the plane of the joist—not any concentrated loads, lateral loads, or any loads acting outside the plane of the joist. Open-web steel joists are not recommended for carrying bi-axial bending.

- Joists should be spanned in the direction of the roof slope, if possible.

- If joists are spanned at right angles to the roof slope, the engineer of record should provide design calculations that address all sizes of joists spanning various distances for different conditions. Where any loads hang from the bottom of joist chords, special attention and calculations are required.

- A row of bolted bridging is required at or near mid-span for joists 40’ or longer.

- When cross-bridging is specified, horizontal bridging units should be used in the space adjacent to the wall to allow for proper deflection of the joist nearest the wall.

- Check minimum depths required for sloping bearing seats.

- Where uplift forces due to wind are a design requirement, specify uplift bridging near the first bottom chord panel at each end of the joist.

- OSHA safety standards for steel erection require that open-web steel joists on or near column lines to be bolted for erection safety.

- Provide KCS joists to support uniform loads plus concentrated and non-uniform loads.

- Where bottom joist chords bear on masonry walls, force transfer mechanisms should be specified to stabilize the joists at bearing and to bring the diaphragm force from the roof deck down into the wall.

- Load diagrams should be provided for special loading conditions.

- Field modifications of joists or joist seats should not be allowed.

- Bottom chord extensions of joist girders should not be welded to stabilizer plates (6”x6”x ¾” plate minimum) unless the design requires use of joist girders as moment resistive frames.

- When using joist girders as moment resistive frames, design connections and columns in accordance with loading conditions.

- Minimum depth of joist seats should be specified.

<u>Masonry</u>

- Bond beams and masonry wall corner reinforcement should be specified, and horizontal masonry ties should be provided at wall intersections.

- Control joints should be specified near corners and at exterior wall openings (on both sides if an opening is wider than ten feet (10’). Space between control joints should be no greater than 25’ on exterior walls and 40’ on interior walls. Control joints should be detailed. Avoid control joints that occur through lintels.

- Reinforced masonry piers that support roof structure should be identified and dimensioned on foundation plans.

- Lintel schedules, with bearing lengths and details, should be provided on plans.
- Weep holes above finish grade should be specified.
- Minimum seismic reinforcements should be specified and designed as required.
- Provide close field supervision for construction of reinforced masonry piers and pilasters.
- Provide adequate lateral supports for masonry walls to ensure code performance compliance.
- Vertical reinforcement extended into the bond beam at the top of a wall should have a 90-degree hook in high wind areas. Cells at reinforcement should be filled with 3,000 psi pea gravel concrete.
- Steel columns are recommended in lieu of reinforced masonry piers to support main roof beams and trusses because they:
    - Clarify the geometry.
    - Provide positive support.
    - Present fewer field control problems.
    - Eliminate the potential for improperly located reinforcement in masonry piers.
    - Minimize masonry wall cracking at pilasters.
    - Allow the roof to be framed before masonry construction is completed.

### Framing Systems

- Complete structural connection details that include gusset plate size of welds, and numbers and sizes of bolts should be provided.
- The tops of steel elevations should be noted on framing plans.
- Design and provide, for all roof trusses, configurations that show bearing locations and member sizes and specify force for each member.
- Bottom chords of roof trusses should not attach to non-load-bearing interior walls.

- Properly flag section cuts on framing plans.

- Indicate all structural components on framing plans, clearly defining shear walls, moment frames, and both vertical and horizontal diagonal braces used to stabilize the building.

- All steel members exposed to weather should have hot-dipped galvanized coatings. "Weathering" steel should not be used.

- Connections:

  - Beam-to-beam connections should develop half the total uniform load capacity for the given section and span.

  - Cantilevered beam connections should develop the total capacity of the beam in both shear and moment.

- Designs for folding partitions supports should take into account the weight of the partition when gathered at the ends and provide adequate lateral bracing to accommodate it.

- For quality and vibration control, composite floor construction is recommended.

- Deflection limitation is L/360 for metal wall cladding and L/600 (or less than 3/8") for brick veneer.

- Exterior stud walls serve a structural function. Design and detail studs, tracks, bridging, and connections. Provisions for jambs, heads, and sills at exterior stud wall openings should be specified.

- A bracing frame system should be designed for roof trusses to provide stability during steel erection and for the completed structure.

- Demolition of structural members should not be left solely to the contractor. Where the design for demolition or renovation of existing buildings involves replacing or removing structural members, the method for their removal and for the shoring of remaining structural members should be detailed on the contract documents.

- Vertical slotted holes should be used for the connection between steel perimeter beams and exterior walls to allow deflection of beams under load. Locate connections for easy visual field inspection.

- Stair details should be shown on structural drawings; there may be many unusual structural problems for which the structural engineer is responsible.

## Pre-engineered Building Systems

- See Department of Public Instruction publication "Pre-Engineered Buildings" available on the School Planning website (www.schoolclearinghouse.org).

## Modular Building Systems

- See Department of Public Instruction publication "Facilities Guidelines" available on the School Planning website (www.schoolclearinghouse.org).

# Plumbing

## General

- Plumbing plans shall bear the seal of the engineer responsible for their design. The engineer or his designated representative must also perform construction administration and issue a certificate of compliance upon completion of the project per G.S. 133-1.1.

- Fire and smoke rated construction shall be shown on all plans.

- Provide all applicable UL fire stop penetration details on plans.

- A complete summary of new and existing plumbing loads, in fixture units, shall be shown on the plans.

- Record drawings should be provided to the owner at the completion of the project.

- Provisions related to accessibility for the physically handicapped, as applicable to plumbing systems, shall be in compliance with ADA accessibility guidelines and North Carolina State Building Code requirements.

### Drain, Waste, and Vent Systems

- Piping shall be cast iron, PVC, or other approved pipe as required/allowed for the application.

- In the expansion of waste systems that currently have terra cotta pipe, existing pipe should be replaced with PVC, cast iron, or other approved pipe.

- Floor drains shall not be installed in food storage areas.

- Floor drains shall be provided for boiler rooms and for mechanical equipment rooms that contain equipment such as cooling coils and water piping systems.

- Two well-separated floor drains should be provided in gymnasium laundry rooms.

- Floor drains of not less than three inches in size should be installed in toilet rooms containing more than one flushing fixture and wherever water heaters are located. Floor drains may be excluded for under-counter water heaters where there is provision for proper disposal of relief valve discharges. Infrequently used drains should have traps resealed by waste from clear-water fixtures. Trap primers are not recommended. Provision should be made for the resealing of floor drain traps in spaces used as return air plenums, and four-inch minimum drains with sediment strainers are recommended.

- Acid-resistant waste lines shall be provided for all science rooms (not dedicated to physics) in high schools and middle schools. Refer to North Carolina Board of Education's "Science Facility Planner" and "Science Safety Checklist" for further guidance.

- Plaster or interceptor traps should be provided for all sinks in art classrooms.

- Vent piping shall be a minimum of two inches in diameter at roof penetration.

- Cleanouts in horizontal pipe runs should utilize long-sweep quarter-bends or fittings providing one-eighth turn. Standard quarter-bends should never be used.

- Roof drainage shall be designed, as a minimum, in accordance with the North Carolina State Building Code.

- For interior roof drain systems, drains and flashings should be furnished and installed by the general contractor and piping should be installed by the plumbing contractor.

Sewage Disposal Systems

- Locations and invert elevations of connections to public sewer systems shall be shown on plans.

- Where a new on-site sewage treatment plant or an addition is required, the following apply.

    - North Carolina Department of Environment and Natural Resources shall be consulted prior to the procurement of a site where on-site treatment or disposal is proposed.

    - Approval must be obtained from North Carolina Department of Environment and Natural Resources to expand any school building that uses on-site wastewater treatment.

    - Plans for treatment plants shall include complete details and elevations of all units and appurtenances, to include profiles from buildings to final point of disposition.

    - Plans and specifications for proposed new treatment plants or additions should be prepared according to North Carolina Department of Environment and Natural Resources recommendations and submitted for their approval.

    - For plants that discharge to the land surface or surface waters and for ground absorption systems, application shall be made to North Carolina

Department of Environment and Natural Resources for approval of the new or existing site and proposed system and plant.

    - Exclude garbage grinders and disposals from all kitchen designs where on-site wastewater treatment systems are used.

- Plans for all work must clearly indicate whether disposal is to a municipal or an on-site system.

- Where disposal will be to a municipal system, confirm that the system can accept the additional load.

- Plans shall provide profiles of sanitary sewer lines between manholes.

Grease Traps

- Waste from food disposal units shall not pass through grease traps.

- Interior grease traps shall not be used.

- Exterior grease traps shall be installed where applicable for the containment of grease waste from kitchens. A standard tank approved by the North Carolina Department of Environment and Natural Resources (1000-gallon minimum) is required.

Water Supply Systems

- Well sites shall be approved by the North Carolina Department of Environment and Natural Resources. Wells shall be located away from possible sources of contamination and properly protected. Well sites shall be shown by areas, rather than by specific locations.

- Where well-water systems are proposed, owners, engineers, and architects should consult the North Carolina Department of Environment and Natural Resources for geological data.

- Plans shall show the well location and complete details of the well supply system, to include the well, pump house, piping, and storage tank. If a pressurized storage tank exceeds 120 gallons nominal capacity, it shall be of ASME construction and shall be registered with the National Board (NCBPVR). When an elevated tank is installed, a fire hydrant shall be properly located on the site or a hose connection shall be provided on the standpipe, or both. With any type of on-site supply system, reasonable and appropriate fire protection equipment should be installed. When new well supply systems are used, provision for continuous chlorination is mandatory.

- If water is to be obtained from a public system, plans shall show the location and size of the supply connection, backflow preventer, and meter. Pressure-reducing stations should be used where supply pressure exceeds 80 psig.

- Water supply systems shall be disinfected before being placed in service.

- The engineer shall designate the water supply source and the size of existing pipes on the plumbing drawings.

## Hot Water Heating

- Dish washing and showering comprise the largest demands on water-heating equipment. These two water-heating demands should be generated and controlled separately. Kitchen hot water demands require a minimum of 140-degree water and should supply only the kitchen. Other small hot-water requirements may utilize electric water heaters (storage type or instantaneous). All water heaters should be placed where the components can be easily maintained.

- If tempering valves are used, they should be located in mechanical rooms that are as close as possible to the points of use.

- 180-degree water heaters should carry the NSF label, or equal (NSF Standard 5). If oil-fired heaters are used, the design shall ensure that there will not be a dip below 180 degrees in the supply temperature during a purge cycle.

- Hot water from water heaters to dishwasher booster heaters should be recirculated by pumping to maintain maximum temperature at boosters.

- Water heaters and storage tanks shall have safety valves sized and installed as required by the North Carolina Department of Labor, Uniform Boiler and Pressure Vessel Act of North Carolina. Dip tubes shall also conform to the requirements of the North Carolina Department of Labor, Uniform Boiler and Pressure Vessel Act of North Carolina.

- Hot water storage equipment shall have linings that prevent interior corrosion. Specifications may include one alternate bid for nickel-lined, copper-clad, or stainless steel that provides a 10-year, non-prorated warranty.

- Electric water heaters of all types shall conform to the NEC Article 422-14 and North Carolina State Building Code requirements for the UL label. Control voltage should be volts-to-ground, such as 120 volt or 277 volt. Water heaters should be controlled by the building energy management system.

- Circulators (pumps) for domestic hot water should be of all-bronze construction. Control should be by the building energy management system.

- Recirculation from the most distant fixture or group of fixtures. The smallest available re-circulation pump is usually sufficient. Consider low-flow fixtures, despite the corresponding longer hot water delivery time.

## Valves and Fittings

- A hose bibb with removable handle or key-operated lock should be installed in any toilet having a floor drain. Hose bibs should have a minimum floor clearance of 18 inches.
- Each fixture should have an individual water supply cut-off valve.
- Flush valves shall be equipped with vacuum breakers.
- In exterior installations, care should be taken to prevent freezing. Freeze-proof wall hydrants should be keyed.
- Hose bibs and wall hydrants with hose threads shall have back-flow prevention devices.
- Lavatory waste fittings should be cast brass, as opposed to tube construction.
- Lavatories should be acid resisting and have rigid supplies. Beehive or grid-type strainers shall be used.
- Supply pipe, valves, and fittings that are concealed (e.g. beneath a counter top) need not be of the rigid type and need not be plated.
- Isolation valves should be placed in positions that will allow ease of servicing by those who maintain the system.
- Water hammer arrestors should be provided as recommended by PDI or ASPE.

## Plumbing Fixtures

- Elongated bowls and open-front seats without covers shall be used for water closets.
- Fixture schedules on plans are sometimes incomplete. Trim should be specified completely to maintain high quality.
- Outside drinking fountains shall be frostproof, with all wastes carried to dry wells or storm drains. Dry wells shall be located at least 50 feet from water supply wells.
- Counter-top sinks should have ledges with holes to receive faucets. Faucets should not be mounted directly in counter tops.

- Water fountains should be located in gymnasium dressing rooms or outside in the corridor.

- An eye wash should be located in the health room area. Consider a lavatory mounted unit.

- Wall-hung urinals with shields are recommended.

- Locate toilets for students and teachers so that no person will have to travel more than 200 feet for access.

- Provide one shower per four persons in physical education at the time of the largest anticipated class.

- Water fountains shall not be located in areas with wood floors, such as gymnasiums and performing arts classrooms.

- Minimum facilities shall be provided in accordance with the North Carolina State Building Code (plumbing) chapter four, table 403.1.  Additional fixture requirements for schools can be found in paragraph 403.9.

## Fixture Mounting Heights

* All required accessible fixtures shall be mounted in compliance with Accessibility Requirements (ANSI  A117.7).

| Grades | | Regular Fixtures | ADA Fixtures | Remarks |
|---|---|---|---|---|
| **Water Closets** | | | | |
| PreK-3 | H/C | | * | |
| 4-7 | H/C | | * | |
| 8-12 | H/C | | * | |
| PreK – 5 | | 15” Seat | | |
| 6-8 | | 15” Seat | | |
| 9-12 | | 15” Seat | | |
| **Urinals** | | | | |
| PreK – 7 | H/C | | * | |
| 8-12 | H/C | | * | |
| PreK – 3 | | 14”-17” rim | | |
| 4-5 | | 17”-20” rim | | |
| 6-8 | | 20”-24” rim | | |
| 9-12 | | 24” rim | | |
| **Lavatories & Sinks** | | | | |
| PK-K | H/C | | * | |
| 1-7 | H/C | | * | |
| 8-12 | H/C | | * | |
| PK-K | | 24” Countertop | | |
| 1-5 | | 27” Countertop | | |
| 6-8 | | 31” Countertop | | |
| 9-12 | | 31” Countertop | | |
| **Water Coolers** | | | | |
| PK-7 | H/C | - | * | |
| 8-12 | H/C | - | * | |
| PK-3 | | 27” spout | | |
| 4-5 | | 31” spout | | |
| 6-8 | | 34” spout | | |
| 9-12 | | 34” spout | | |

Showers

| | | |
|---|---|---|
| K-5 Boys & Girls | 50”-56” spray head | 11”-17” high seat.<br>36” AFF controls if<br>60” flexible hose |
| 6-8 Boys<br>height. | 72” spray head | 17” seat<br><br>36” AFF controls if<br>60” flexible hose |
| 6-8 Girls | 60”-66” spray head | 17” seat height.<br>36” AFF controls if<br>60” flexible hose |
| 9-12 Boys<br>height. | 78” spray head | 17”-19” seat<br><br>36” AFF controls if<br>60” flexible hose |
| 9-12 Girls<br>height. | 72” spray head | 17”-19” seat<br><br>36” AFF controls if<br>60” flexible hose |

(Grade 7 is assumed to be age 12.)
(Grades 8-12 ADA requirements are the same as for adults.)

Kitchen Plumbing

- A service sink or a receptor shall be located in the kitchen area.

- A lavatory with a mixing faucet shall be provided in the kitchen area for hand washing and shall be located in accordance with North Carolina Department of Environment and Natural Resources.

Gas Systems

- Gas systems, whether for LP or natural gas, shall conform to the North Carolina State Building Code.

- Special concern should be paid the following areas in the Code:

    - Kinds and types of pipe that are acceptable for gas

    - Allowable pipe installation methods with regard to routing, placement, special treatments, and valving arrangements.

- Metal pipe—not tubing—should be used for gas systems. Welded joints for larger sizes are considered good practice.

- Where it is necessary to install gas pipe under a building floor slab, the piping shall be encased in wrought iron, PVC (schedule 40), or steel pipe. Casings shall be tightly and permanently sealed and vented to the outside of the building.

- A 100 psi air test, with soap solution applied to all joints, should be specified for all gas piping.

- Where applicable, the engineer should specify that a permit be obtained for the installation of gas appliances and that local inspection of the work be requested.

- In locating gas-fired water heaters, the engineer shall ensure that there will be adequate air for combustion and proper ventilation for the space.

- Gas piping to laboratory casework shall have a shut-off valve located in a lockable panel or in a lockable section of the instructor table. See North Carolina Board of Education “Science Safety Checklist” for further requirements.

- Vent lines from gas-fired appliances and devices shall terminate outside the building.

# Heating, Ventilating and Air Conditioning

## General

- Boilers, water heaters and tanks shall comply with the North Carolina State Building Code ( Mechanical and Plumbing) and the North Carolina Department of Labor Uniform Boiler and Pressure Vessel Act of North Carolina, as required based on size and capacity.
- All fire and smoke rated construction as well as each required duct mounted fire damper or smoke damper shall be shown on each plan. Include all applicable fire and smoke rating symbols in legend.
- Provide UL fire stop penetration details on the plans for each type of penetration.
- Motor overload protection shall be specified to be in accordance with NEC. For three-phase motors, protection shall be provided for each of the three phases.
- A complete heating and cooling summary shall be shown on the plans and shall indicate:
    - The existing load. Where this information is not readily available, the owner should make arrangements to provide it to the designer
    - The new heating and cooling loads
    - Capacity provided for known future expansion
    - Net SBI or IBR capacity of the boiler(s), where applicable
- Air-handling units shall not be located in rooms that contain boilers.
- Heating and cooling design conditions shall be stated on the plans.
- Mechanical plans shall bear the seal of the engineer responsible for their design. The engineer or his designated representative must also perform construction administration and issue a certificate of compliance upon completion of the project per G.S. 133-1.1.

- The engineer should select HVAC equipment with a low noise level that does not hinder instructional activity.  Noise levels in classrooms should not exceed the level of NC 30.

- Record drawings should be provided to the owner at the completion of the project.

- Proper clearances for service and maintenance procedures shall be provided when positioning HVAC equipment. It is not desirable to have equipment located where service procedures require ladder access or where ceiling grids or building structure must be removed for equipment replacement.

- When located outside, HVAC equipment should be enclosed to prevent unauthorized access and malicious damage.  Chain link fences and brick walls with gates are examples of typical enclosures.

## Selection of a System

In the design of an HVAC system for a school, the following are some factors and objectives that need to be considered as a part of the selection process:

- Room temperature and humidity control
- Times and loading of occupants in spaces
- Ventilation rates and indoor air quality
- Control of noise in the classroom environment
- System Life Cycle Cost
- Energy use and efficiency
- Ease of operation and maintenance
- Reliability of the system and long life of the components
- Flexibility and adaptability of the system
- Space requirements and/or availability of space
- Types of fuels available

- Energy management control systems

The most common indoor environmental complaint is poor ***temperature control***. The ideal solution is to have individual room temperature control for each classroom. The next step down in temperature control would be to have groups of two or more classrooms each having the same directional exposure be controlled from a single thermostat. Temperature control will be lost, to some degree, when some classrooms are vacated for a period of time while others are not.

The design should provide for control of ***relative humidity*** at or below 60 percent in all spaces. More precise control will be required in certain areas, such as the media center.

Areas such as auditoriums, cafeterias, and gymnasiums have high ***concentrations of students*** for short periods of time and should be controlled separately from other spaces. Other spaces, such as offices, may have a very different ***time of occupancy*** than the classrooms and other areas of the building and may need to be on a system separate from the central system.

***Noise*** emanating from HVAC equipment within the classroom can be disruptive to the teaching/learning process. The worst acoustical arrangement is packaged equipment, mounted inside the classroom that contains the compressor with supply air discharge directly from the unit without the use of ductwork. Unit ventilators or fan coil units, with only a fan, mounted on the floor or at the ceiling can also be quite noisy. Often a child's desk is placed close to one of these units and that child is at a disadvantage. The best arrangement, acoustically, is to remove the mechanical equipment from the classroom using ductwork to transmit the heating and cooling to the classroom.

The ***energy efficiency*** of a system or component should be given strong consideration. When available, lower-cost fuels should be used. Reheat systems should be avoided except in the case of a dehumidification cycle required in an area such as the media center.

Systems that are ***difficult to maintain*** invite situations where the equipment is not properly maintained and the result is sometimes equipment failure and indoor air quality problems. Systems that require maintenance within the classroom or above ceilings (from ladders) should be avoided where possible. Rooftop equipment is often not well maintained, especially when good access is not provided. The most desirable arrangement is to have the mechanical equipment floor mounted in mechanical rooms or on mezzanine equipment spaces that have stair access from a space large enough to hoist equipment up or down to the main level.

System ***reliability*** is generally determined by good design, proper installation, equipment maintenance and component life.

The system design may need to provide the flexibility to accommodate changes in classroom function or future school expansion. It might be feasible to provide spare capacity in some components, such as boilers or chillers.

## System Types

### Recommended Systems

The following components of a system are recommended because they provide long-term reliability, excellent room temperature control, low operating cost, moderate first cost, low room noise level and ease of maintenance.

A. Central Air-Cooled Chiller(s)

B. Natural Gas Fired Central Condensing Boiler(s)

C. 4-Pipe Chilled Water/Hot Water Variable Volume Piping System

D. Air Handling Units (AHUs) in localized Mechanical Rooms or Mezzanine Areas Providing a Separate Zone for Each Individual Classroom

The following are possible alternatives to the above-recommended system:

| ALTERNATIVE COMPONENT/SYSTEM | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| | | |
| Same system except each AHU serves 2-5 classrooms | Slightly lower first cost | Having more than one classroom on a single thermostat is a compromise in comfort. |
| Fan Coil Units or unit ventilators mounted above ceiling in each classroom or corridor with ductwork and diffusers<br>This system should only be considered for existing building renovations where space is limited. | Individual room control<br>Moderately lower cost than AHUs<br>Does not occupy floor space | Noisy.<br>Difficult to service. (ladder)<br>Routing of condensate drain line can be difficult.<br>Moderate life of unit. |
| Unit ventilators, console or exposed below/at ceiling<br>This system should only be considered for existing building renovations where space is limited. | Individual room control.<br>Slightly lower cost than AHUs. (no ductwork required) | Noisy.<br>Fresh air is difficult for interior spaces.<br>Take up space under windows (console units).<br>Care must be taken to avoid coil freeze-up in console units.<br>Unsightly if piping is not concealed.<br>Better filtration not possible |
| Water-cooled Chiller (in lieu of air-cooled) | Good performance and reliability<br>Energy efficient | High first cost.<br>Maintenance/treatment of cooling tower not practical for most school systems. |
| VAV system with separate zone for each classroom. Typically one large AHU per wing | Excellent individual room control. | Higher first cost.<br>Higher maintenance cost. |

| | | |
|---|---|---|
| Hydronic Heat Pumps | Relatively low first cost.<br>Individual room control.<br>Only one uninsulated pipe loop required.<br>Energy savings during simultaneous heating/cooling. | Multiple compressors to maintain.<br>Cooling tower maintenance.<br>Noisy if mounted in or above classroom. |
| Geothermal (ground-coupled) Hydronic Heat Pumps | Individual room control. Good reliability.<br>Very low operating cost.<br>No above-ground outdoor equipment required.<br>Renewable energy source (environmentally friendly). | Drilling of wells and ground loop piping is costly. Requires a lot of land for wells and even more for horizontal loops.<br>Multiple compressors to maintain.<br>Cooling tower service in hybrid systems.<br>Noisy if mounted in or above classroom. |

## Boilers

- Boiler room floors should be located at or above grade elevation.
- Boilers and pressure vessels shall be installed with adequate clearance for operation and inspection.
- For tube cleaning and removal, steel boilers shall have minimum front clearance equal to the length of the longest tube plus 12 inches.
- When sections are added to a cast iron boiler, the nomenclature plate and safety valve shall be changed to comply with the new rating.
- Boiler ratings

    1. The SBI net ratings should be shown for steel boilers. Boiler selection should be made with respect to load, piping, and pick-up.
    2. The IBR net rating for cast iron boilers should be specified.
    3. Where catalogs show only gross boiler ratings, care should be taken to determine true net ratings. Selection should be made with respect to both direct connected load and necessary piping and pick-up losses (as applicable to schools).

- Safety and relief valve capacities shall be specified on the plans.
- Safety and relief valve discharges shall be installed in accordance with the North Carolina State Building Code (Mechanical and Plumbing) and the North Carolina Department of Labor Uniform Boiler and Pressure Vessel Act of North Carolina.
- Discharge lines from safety and relief valves shall be supported other than by the valves themselves.

- Manholes, rod holes, nomenclature plates, or ASME stamping on boilers shall not be covered or obstructed by other components.

- Boiler piping should not restrict the use of clean-out doors, manhole openings, and plugged openings.

- A four-inch thick (minimum) concrete base should be installed under a boiler.

- Heating fuel should be light oil or natural gas. Where natural gas is available, dual fuel burners for both gas and oil should be used.

- Make-up water to boilers should be introduced at the return connection to the boiler or to the air line for an expansion tank.

- Gas burners for boilers firing may be of the atmospheric (non-pressure) type in the lower range of sizes (up to approximately 500,000 btu input). Above that size, power burners should be used. Factory-engineered units incorporating boiler and burner are recommended.

- Proper application and use of the best available grades of gas combustion equipment and safety controls are mandatory. Equipment and controls should be specified in strict accordance with manufacturers' recommendations and best accepted practices, and shall meet requirements of the AGA. Combustion control equipment to provide the degree of performance and safety needed in school applications.

- The net free area of boiler room combustion air louvers shall meet the requirements of the North Carolina State Building Code (Mechanical and Plumbing) and the North Carolina Department of Labor Uniform Boiler and Pressure Vessel Act of North Carolina.

<u>Stack and Breeching</u>

- <u>Stack</u>

    1. A hinged cleanout door should be specified for the chimney.

    2. A flue lining is required (North Carolina State Building Code, Mechanical) and should be coordinated with the architect.

    3. A pre-cast flue thimble or firebrick lining is necessary where the breeching enters the chimney, and should be coordinated with the architect.

4. Thimble, breeching and chimney connections must be airtight for efficient operations.

5. Where metal chimneys are specified, as for oil- or gas-fired equipment, provisions of the North Carolina State Building Code, and NFPA 211 shall apply.

- Breeching

1. Breeching should be supported independent of the boiler.

2. Adequate cleanouts should be provided to promote easy periodic cleaning.

3. In forced-draft applications, barometric dampers are not usually required.

4. In forced-draft boiler installations, a locking-type damper should be installed in each separate breeching.

## Oil Storage Tanks

- Oil storage tank capacity should reflect the size of the heating plant and local service and delivery options. A minimum capacity of 10,000 gallons is normally necessary to attain fuel cost savings through central purchasing. Check with owner before finalizing tank size.

- Where underground tanks are necessary, they should be fabricated of heavy steel or fiberglass, should be double walled, and should bear the Underwriter's label. Steel tanks should be fiberglass coated.

- Underground tanks should be adequately anchored by means of concrete pads and/or suitable anchor hardware.

- Tanks shall be installed in strict accordance with governing building (fire) codes and environmental regulations.

- Above-ground tanks, with properly designed and constructed containment, are preferred.

## Hot Water and Chilled Water Piping

- Heating or cooling pipes should be placed underground or below slab on grade only if there is no other option.

- Where it is necessary to install piping underground, piping should be located outside the periphery of the building wherever possible, rather than beneath the slab. Pipe tunnels might be feasible in some applications.

- Exposed outdoor water piping should be protected from freezing with electric heat tape or a glycol solution. When glycol is used, heat exchangers should be incorporated into the piping loop to prevent the circulation of glycol through the building or coils (due to reduced coil efficiency). Insulation should be covered with a protective metal covering.

- Provision for expansion of piping should be provided by use of expansion fittings, swing joints, or expansion loops.

- Provision should be made for the removal of valves, strainers, etc. through the use of unions, except where fittings are of the combination union or flange types.

- Piping hook-up details should be shown on plans for each piece of heating and cooling apparatus, to include boilers, chillers, cooling towers, pumps, coils, heat exchangers, radiation units, forced air heating and cooling units, and any points where special piping conditions exist.

- All manual balance valves and automatic flow control valves should be installed on the leaving side of the coil, after the control valve, to reduce coil noise and air problems.

- Pumps shall have a cut-off valve on each side for servicing. One of these valves may be a combination shut-off, center guided non-slam check, and balancing valve. The engineer should specify the minimum CV of the valve.

- Pipe insulation in boiler rooms and mechanical rooms should have protective canvas applied over the insulation system. Jackets provided as a part of the insulation system are not sufficient.

- Flow direction arrows for all heating and cooling (water) lines should be shown on plans.

- Locations of piping runs, such as above-ceiling, exposed at the ceiling, or below floor, should be indicated by notes on drawings.

- Provide valved fill bypasses around pressure regulating valves in make-up water assemblies serving hot water or chilled water piping systems. Provide a pressure gauge and cock.

- Isolation shut-off valves should be provided at each location where piping enters or leaves a mechanical room or a building. Provide valving that is easily accessed for isolation of each wing of a building.

- Provide air control systems for hot water and chilled water systems. The air control system is to consist of ASME compression tanks, tank fittings, drains, properly sized pressure reducing valves and air separators with tangential connections. Show on the plans the pressure required at the pressure reducing valve to provide 4 psig pressure at the high point of the system with the pump off.

- Compression tanks shall be specified to meet ASME Code construction and should be so stamped. Bladder-type tanks may be used in lieu of compression tanks. Sight glasses should not be installed on tanks unless they are equipped with isolation ball valves.

- Reverse return design is recommended for hot water and chilled water piping systems, where practical. Automatic flow control valves may be used as an alternative, installed on the leaving sided of the coil after the control valve. A strainer with hose bibb blown-down valve shall be installed on the entering side of each coil. Automatic flow control valves and strainers should be the same size as the piping, except at the connection to the modulating control valve where they can be reduced no more than one pipe size. The engineer should specify the minimum CV of the valve. Arrangement should be such that water flow is equally divided through each boiler. Pumping shall be away from boilers and to the system.

- Manual air vents, rather than automatic, should be used.

- Provide a system piping flow diagram on the drawings for both chilled water and hot water systems.

- All modulating control valves, combination valves, check valves, balancing valves, strainers and on/off valves should have their minimum CV or maximum allowable pressure drop specified, to control the hydronic system efficiency.

- All pump schedules should include pump efficiency, maximum allowable suction and discharge velocities or minimum connection sizes, along with the NPSHR for all cooling tower pumps.

- Plans or specifications should call for all piping in boiler rooms, mechanical rooms and other accessible locations to be labeled.

## Heating Systems

- The North Carolina State Building Code does not permit any type of direct-fired gas heating system inside the school building.

- Individual control valves should be sized large enough not to restrict capacities. Two-position valves should be full pipe size.

- Control valve actuators need to be sized to fully close against the full shut-off head of the pump.

- Modulating control valves should be sized with a wide open pressure drop enough to offer good control through the full range of operation. Usually a valve pressure drop of approximately 25% of the system pressure drop is adequate.

- To prevent cold operation, strap-on limit controls should be installed on unit cabinet heaters not also used for ventilating and cooling. For example, unit heaters in shops that circulate air separate from heating may include an additional on-off automatic hot water control valve to accomplish this.

- Valves and balancing cocks should be accessible—not behind covers without access panels.

- Fronts and ends of radiation covers should be a minimum of 16 gauge steel.

- For reasons of economy, installation of full standby pumping is not recommended. When warranted, a spare motor can be provided.

## Cooling Systems

- Cooling should be specified for the entire school facility, with the exception of mechanical/electrical equipment rooms, janitor rooms and certain storage rooms.

- Specific humidification control should be provided in areas such as media and technology centers, computer rooms, and uniform and musical instrument storage areas.

- For small fan coil units two-position (on-off) control of chilled water coil control valves is preferable over modulating control because of better space humidity control.  If modulating valves are used, the system should include a dehumidification sequence of operation.

- When multiple chillers are used, terminal cooling coils should be controlled with two-way valves and variable-speed pumping should be used.  This allows the first chiller to fully load up at part load and results in a more efficient system.

- In central-plant air conditioning systems, types of refrigeration equipment --- rotary, centrifugal, air-cooled or water-cooled --- should be evaluated and selected carefully, based upon capacity, flexibility, space requirements, noise and vibration factors, operation and maintenance requirements, and load diversity.

- Self-contained, unitary air conditioning equipment is acceptable, but should be carefully evaluated with respect to life expectancy, efficiency, service, and noise factors.

- Window-type air conditioning units are not recommended and should only be selected as a temporary last resort.  They should not be used in classrooms.

- Larger group toilets should be cooled and heated.

- Heat reclaim equipment should be used for fresh air intake if it is found to have a reasonable payback in operating cost savings.

- Five-year warranties should be specified for air conditioning compressors.

- Noisy outdoor equipment should not be placed adjacent to classroom windows or in other areas where a distraction might result.

## AHU, Fan Coil and Unit Ventilators

- Flexible connections should be provided at all ductwork connections to units.

- Condensate drain pans should be positively sloped with the outlet in the bottom of the pan so that water never collects in the pan and supports microbial growth.

- Provide air-handling units with metal filter access racks and hinged filter access doors with cam locks.

- Filters with a minimum MERV rating of 8 should be specified and maintained in units. Better filtration will remove a large part of the fungi and bacteria that tend to collect on the wet cooling coil. It also deprives the microorganisms of nutrients (dust, lint, etc.) that are necessary for growth. Cleaner, more efficient coils will offset the slightly higher cost of more efficient filters.

- Low-leakage dampers should be specified for fresh air intakes. Damper controls shall have the dampers positively closed when the units are off.

- Units should be supported on vibration isolation equipment. Special attention should be given units mounted on the floor of the second level.

- Do not locate air handling units in the same room as boilers.

- Auxiliary drain pans shall be mounted below units that are installed above ceilings or on the second level without floor drains. The drain pan shall include a float switch that will stop the unit if water collects in the auxiliary pan.

- Adequate service space is essential for air-handling and fan coil units.

## Air Distribution

- All ductwork fabrication and installation should meet SMACNA recommendations.

- Ductwork, excluding transfer ducts, requiring insulation should be insulated externally. Ductliner should be avoided unless used in double wall applications.

- Ceiling diffusers in classrooms should always be the adjustable-throw type.

- For classrooms 1,000 square feet or less, a total of four (4) four-way ceiling diffusers are recommended.

- Provide at least three (3) diameter of straight flex duct at the diffuser inlet.

- Provide a balancing damper at each branch duct takeoff from the main duct so that air balancing can be done at that point rather than with the diffuser damper.

## Ventilation and Indoor Air Quality

- Mechanical ventilation may be provided by means of either separate fresh-air intake systems (with or without accompanying exhaust) or integration with the heating-cooling system.

- Classroom ventilation rate should be 7.5 cfm of fresh air per person. Louvers and fresh air ducts only (fans and heating/cooling capacities shall be based on 7.5 cfm per person) should be sized to handle 15 cfm per person for future special ventilation needs.

- Avoid pulling fresh air off flat roofs because of roofing odors, high temperatures and standing water.

- Where ventilation air is introduced in excess of exhaust air makeup requirements adequate provisions should be made for air relief.

- Mechanical ventilation is essential to locker rooms, certain storage rooms, dressing rooms, laundries, toilets, and janitor closets.

- Year-round operation of ventilation equipment in uniform storage areas is recommended.

- Sound traps should be installed in duct systems serving two or more toilets or the ducts should be offset so there is no direct path between the toilets for sound to follow.

- Paint spray rooms are considered hazardous and require special ventilation and safety treatment. Commercial booths are recommended. Where other equipment is installed, related regulations and codes should be carefully investigated.

- Adequate quantities of make-up air shall be provided in spaces equipped with exhaust fans. Filtering and tempering of make-up air is appropriate for some applications.

- Gutters are prohibited on kitchen exhaust hoods. Hoods should be mounted a minimum of six feet, six inches and a maximum of seven feet from the floor. Hoods shall cover the entire area of cooking equipment and extend at least six inches beyond the equipment. Automatic fire extinguishing equipment shall be installed in the kitchen hood (North Carolina State Building Code). Fuel systems shall be shut-off upon activation of the fire extinguishing system.

- Capacity of range hood fans should be approximately 100 cfm per square foot of hood area or as recommended by an approved manufacturer. Exhaust air should be discharged straight up through the roof or appropriate clean-out doors provided in the exhaust duct if turns are made.

- Exhaust canopy hoods and fans should be installed over kilns. The hood should be no more than two feet above the kiln. Adequate makeup air should be provided for the air that is exhausted to the outdoors.

- An exhaust system is required in electrical equipment rooms where significant heat is generated by electrical equipment such as transformers.

- A manually controlled emergency exhaust system shall be provided for each chemistry and science room and a continuously operating exhaust system shall be provided for each science prep room and chemical storage room. See the North Carolina Board of Education Science Safety Checklist.

Controls

- Drawings shall include a control diagram and the corresponding written sequence of operation. The sequence may be included in the specifications.

- All control components including starters, switches, etc. should be permanently labeled after installation.

- Rigid guards should protect thermostats or other vulnerable control items exposed in gymnasiums, locker rooms, shops, corridors, toilets, and unsupervised areas. Thermostat locations shall be shown on plans.

- Control circuits for any type of space-heating device or water heater should be phase-to-ground, 120 volt or 24 volt. Phase-to-phase circuits are not acceptable.

- To conserve energy, time of day controls should be provided for space-heating and cooling equipment and exhaust fans. Use the building energy management system, when available.

- In most instances, cooling equipment should be turned off altogether during periods when buildings are unoccupied, unless needed for humidity control.

- Boiler systems should be designed and controlled in such a manner as to use the least amount of fuel possible in off-heating periods.

## Commissioning

- Properly balanced air and water systems should be specified and proper installation should be assured by the designer.

- Thorough orientation and training on the operation of the system should be provided for the maintenance staff.

- Piping system cleaning, treatment, and placement into service should be clearly specified and witnessed by the designer.

- Every effort should be made by the designer to assure that the fresh air quantity is set properly and that the school maintenance director/administrator is made aware that, if set too high, operating costs will be high and , if set too low, IAQ problems may result.

# Electrical

## General

- Electrical plans shall include a single-line or riser diagram showing service conduit size, service wire size and type (or bus duct), panels, switches, over-current device sizes, transformers (when used in the secondary system), feeder conduit sizes, feeder wire sizes, and complete grounding and bonding details. Where partial risers are provided the riser shall show how additional panels are connected to the existing building service. Specifications shall describe quality of materials and methods of installation.

- Electrical plans shall bear the seal of the engineer responsible for their design. The engineer or his designated representative must also perform construction administration and issue a certificate of compliance upon completion of the project per G.S. 133-1.1.

- All fire and smoke rated construction shall be shown on each plan. Include all applicable fire and smoke rating symbols in legend.

- Grounding and bonding details shall be shown by means of a diagram.

- North Carolina General Statutes require that all electrical equipment, devices, and apparatus sold and used in the state shall be evaluated for safety and listed by an accredited listing agency (G.S. 66-Article 4). Specifications shall indicate that requirement.

- Electrical plans shall include a numbered circuit diagram for each panel showing circuit use, circuit breaker size, circuit wire size, circuit conduit size, phase loads, AIC, and total panel load.

- An emergency system shall be kept separate from all other wiring (NEC Article 700).

- Where wire and equipment are oversized for future expansion, notation should be provided on the plans to indicate what provisions have been made for the future.

- The entire system shall be color coded. Paint or tape should not be applied to No. 6 or smaller wire.

- Two sets of colors should be used for color coding multiple-voltage systems, such as 277/480 volt or 120/208 volt.  Color standardization for the phase conductors should be red, black, and blue for 120/208 volt systems; yellow, brown, and orange for 277/480 volt systems.

- When long runs of wire are used, voltage drop (independent of spare capacity) should be considered.  The maximum voltage drop should not exceed 5% of the nominal voltage.

- All electrical plans and specifications for powering of heating and air conditioning equipment, general lighting, and plumbing equipment should be coordinated and shall comply with the North Carolina State Building Code.

- Final wiring connections for heating, ventilation, air conditioning and plumbing equipment should be a part of the mechanical/plumbing contract (as applicable). All work installed as part of the mechanical/plumbing contract shall conform to the NEC and, where required, be performed by a licensed electrical contractor.

- Electrical plans shall show the secondary voltage at the single line or riser diagram, in panel and other schedules, and in the lighting fixture listing. Acceptable secondary voltage systems include: 120/240 volt, single-phase, three-wire (for very small facilities),120/208 volt, three-phase, four-wire, wye (for small facilities) and 277/480 volt, three-phase, four-wire, wye (recommended for most new facilities)

- A single-phase system is acceptable only when the system is in an existing facility that is single-phase, in remote locations, if the facility will remain very small after the construction or when it is not possible or economically feasible to extend three-phase service to the school site.

- Delta systems (120/240 volt, three-phase, four-wire) are not recommended and should not be used only for an addition to an existing facility that operates at that voltage and conversion to 120/208 volt, wye is not economically feasible.  Where no existing 240 volt, three-phase equipment is in use, the system should be converted to 120/208 volt.

- For step-down transformers within a secondary system, drawings should show details for transformer wiring, grounding, and bonding.  See NEC Article 450 for over-current protection.

- Conductors supplied from the secondary terminals of dry-type transformers within secondary electrical systems must be provided with over-current protection, in accordance with the requirements of NEC Article 240. See NEC Article 250 for grounding requirements for separately derived systems. Pay particular attention to NEC Article 250-104 D 1.

- Step-down (dry-type) transformer locations are important safety and operational elements. They should never be located in wet areas or in areas that are to be hosed down, and should be mounted at least 6 inches above floor level to eliminate potential water hazards. Transformers should be located in properly ventilated areas such as equipment rooms, closets, or other similar areas not directly accessible to students. Refer to NEC Article 450.

- Specifications shall require all insulated conductors to be marked on their outer coverings to indicate voltage, type, and size for post-installation identification.

- Conductors should be copper wire. Power and Lighting circuits #10 AWG or smaller shall have solid copper conductors. Conductors #8 or larger shall have stranded conductors. Feeders greater than 100 amperes may be copper-clad aluminum with mechanical connectors only in situations where the designer, the owner and School Planning find it to be beneficial. Split-bolt connectors are not acceptable.

- The available short circuit current (or KVA) should be identified on the riser diagram or the load summary and fault current ratings shall be listed on both new and existing panel board schedules to provide awareness to electrical engineers and maintenance supervisors to ensure that proper coordination of electrical systems within the schools will be provided. Refer to NEC Article 110-9.

- Computers, adjustable-frequency drives, ballasts, and numerous other electronic devices now installed in school construction projects cause non-linear loads and harmonics. Oversized neutrals and transformers designed for non-linear loads should be considered and used where necessary.

- Due to the sensitivity of electronic equipment now installed in new construction or renovations, transient and surge protection is usually required. These devices can be installed in service entrance panels or feeders and in panel boards or receptacles serving electronic equipment. Protection may be provided at one or any combination of these locations, based upon professional knowledge and judgment. Protection is required for telephone and data conductors—particularly those that enter the premises from the outside sources and that run from building to building.

- The Americans with Disabilities Act affects numerous functions within the school that include (but are not limited to) sound, telephone, and fire alarm systems for the hearing impaired.  Electrical systems shall be designed to meet applicable requirements of the ADA and NCSBC. Strobe lights or combination strobe/horn units are required for all classrooms, toilets, corridors and other places of assembly, and in specialized instructional areas.   Mounting heights of switches shall be within ADA parameters.

- An electrical summary, either full or in part as is appropriate for a given school, shall be shown on the plans and shall include:

    1. The new load (total connected and calculated demand per NEC Article 220)

    2. The existing load.  If this information is not readily available, the owner should make arrangements to provide it through the services of the design consultant, use of demand readings from the electric utility, or some other means.

    3. The capacity provided for known future expansion

    4. Any specific spare capacity provided, if not for future expansion.

    5. The total capacity of the service.

- A minimum of one 20-ampere circuit should be used for receptacles only in each general classroom.  Additional 20-ampere circuits may be required for computer installation.  Special classrooms can impose different considerations.

- Electrical and mechanical engineers should work together closely to apply reasonable methods of energy management, ensure the control of all aspects of electrical energy usage, and to minimize operating costs.

- In gymnasiums, gymtoriums, play, and other similar indoor spaces, mounting methods for overload lighting fixtures are important.  Fixtures should be mounted as high as possible while maintaining optimal function, be mounted on swivels, and incorporate safety chains.  To prevent injury to students and other from falling fixtures or debris from damaged fixtures, protective lenses or wire cages should be used.

## Service Entrance Feeder

- In addition to locating pad-mounted transformers (when used), the location of the nearest power pole should be shown on the plans.

- Service entrance feeders should be detailed and dimensioned, showing attachment points to structures and clearances of service wires over finish grades, drives, and roofs (NEC Article 230).

- Connections at service heads shall be made in accordance with the requirements of NEC Article 230.

- Underground services, both primary and secondary, should be in conduit and is recommended to be encased except where the cost is unreasonable. Underground service routing should be shown on a site or plot plan.

## Service Equipment and Grounding

- All service equipment, including emergency systems, shall be bonded up to and including the first over-current device (NEC Article 250).

- Bonding requirements shall be included in the specifications or as part of bonding diagrams shown on plans.

- Emergency systems shall be bonded up to and including their over-current devices.

- Surface-mounted switches, cabinets, metal raceways, boxes, and fittings mounted on surfaces subject to dampness shall not be attached directly to those surfaces. At least 1/4 inch of air space shall be provided between such enclosures and walls or other supporting surfaces. Cabinets or cutout boxes installed in wet locations shall be weatherproof (NEC Article 312).

- Cabinets and cut-out boxes in switch gear shall be increased in size to accommodate extra connections (NEC Article 312).

- Each building or structure shall have its own ground and its own disconnecting means as required by the NEC Articles 230 and 250.

- Provide Surge protection equipment at, or as near as possible to, the service entrance or main panel board. Supplemental protection when provided, should be located at or as near as possible for electronic equipment and computers.

- Grounding electrode system connections shall be to the building water main (metallic pipe) and ground rods and shall be accessible. Points of attachment and sizes of grounding electrode conductors shall be indicated on the plans (NEC Article 250).

- Where ground wires are protected by the use of conduits, conduits and wires must be bonded at both ends of the conduits (NEC Article 250).

- Where a 480/277 volt service is used and the main circuit breaker is 1000 amperes or higher, the main circuit breaker shall have a ground fault protection device.

- If non-metallic water supply pipe is used, specify alternative grounding methods. Proper grounding must be established in accordance with NEC Article 250.

- Service equipment shall be referred to as service equipment and shall be third party labeled as such.

- Whenever possible Electrical service equipment should not be located in boiler rooms due to the derating effect of heat on equipment and wiring. Where such equipment must be so located, it should be in a completely separate dedicated enclosure as far away from the heat source as possible. Under no circumstances should electrical equipment be located in a space with propane-fired boilers. Where existing boiler rooms are below grade, renovations should relocate electrical equipment to other more appropriate spaces.

- Strong emphasis should be placed on proper grounding. Many problems that result in equipment failure—particularly in electronic equipment—are caused by poor grounding, even when lightning protection is present.

## Distribution Equipment

- Electrical equipment, such as panel boards, transformers, disconnect switches, and starters, should be located to prevent student accessibility. Whenever possible electrical panels and distribution equipment should be located in dedicated equipment spaces. When this is not possible other possible locations include office areas, storage closets, attics, mechanical equipment rooms, and “dry” custodial storage rooms. Use of storage rooms and Janitor’s closets should be avoided unless other locations are not available. It is common for storage rooms and Janitor’s closets to have material stored in front of NEC required access for panel boards making it difficult to properly access equipment. All equipment shall be located in spaces that maintain the temperature requirements of the equipment.  Rooms that have transformers should be provided with ventilation as a minimum.

- Panel specifications must include special approved lugs where conductors are run in multiple or are used in through-feeders.

- Bolt-in breakers should be used in panels.

- Breakers should be numbered and branch circuits installed as shown on the plans; shop drawings of panels should match the plans.

- More than one solid or stranded wire shall not be allowed under a single lug or screw-type terminal unless approved for such use (NEC Article 110-14).

- Throated, insulated bushings should be used on all EMT connectors.

- Consider harmonic distortion from computers, copy machines, printers, lighting fixtures, and other equipment.  Size feeder and panel board neutrals accordingly and specify transformers for use with non-linear loads.

- Spare conduits should be included where spare breakers are provided in flush-mounted panels.

- Proper panel board protection is required (NEC Article 384).

- Provide lightning and surge protection where television, computer, telecommunications, or other electronic equipment is located.

- The use of transformers to convert 208 volt to 240 volt for use in instructional electric ranges is discouraged.  208 volt equipment should be specified.

- Science Rooms, Prep Rooms and Chemical Storage rooms require special provisions associated with power and illumination of these spaces.  Refer to the North Carolina Board of Education, Science Facility Planner and Science Safety Checklist for requirements and Guidelines.

- Provide proper flash protection labeling for equipment per NEC Article 100.16

## Branch Circuits

- Metal switch and receptacle cover plates are recommended

- Moisture-proof switches and lighting fixtures shall be used in wash areas, shower rooms, freezer and refrigerator rooms, dishwasher locations, and other such places that are likely to be subjected to water or moisture (NEC Articles 314 and 410).

- Use GFI receptacles in exterior locations, within six feet of lavatories or sinks, on roofs, and other wet locations. Whirlpools and Therapeutic pools shall also have GFI protection and meet other applicable requirements of NEC Article 680.

- Do not use flush floor-type receptacles in kitchens or in other spaces subject to washing down or mopping.

- At least one duplex outlet is required in the boiler room and at least one shall be located within 25 feet of each piece of mechanical and plumbing equipment, to include that which is roof-mounted.

- Junction and pull boxes shall, as a minimum, be sized according to NEC 370.

- Provide disconnect switches for water heaters that are located out of sight of the panel boards feeding them.

- Whenever possible provide separate neutrals for each circuit in a multiwire branch circuit in lieu of multipole breakers. See NEC Article 210.4.

- Oversized neutrals shall be used as required where “K”-type transformers supply equipment that produces harmonic distortion.

- All lock nuts must be tightened during installation (NEC Article 300).

- The minimum feeder conductor size shall have an allowable ampacity no greater than 125% of the continuous load plus the non continuous load.(NEC Article 215.2)

- Fluorescent fixtures mounted on combustible, low-density cellulose fiberboard shall be installed as required by the NEC Article 410.136

## Motors and Equipment

- Use Flexible Metal Conduit (FMC) or Liquidtite Flexible Metal Conduit for final connections to vibrational equipment.

- Refer to NEC 430 for requirements for motor overload protection, ground fault protection and wire size.  Each motor shall be within sight of its disconnecting means.  For this application, more than fifty feet shall be considered out of sight.

- New shop and kitchen equipment should be specified to operate from 120 or 208 volt, single-phase or 208 volt, three-phase supply.  Caution should be exercised in selecting 480 volt equipment.

Emergency and Exit Lighting Systems and Power

- Emergency and exit lighting are required for all portions of the means of egress (exit, exit access and exit discharge) by the North Carolina State Building Code. All new buildings, additions and renovated areas of school buildings, regardless of age, shall have both exit and emergency lighting fixtures. Refer to North Carolina State Building Code 1006.2 for illumination levels for the means of egress, including special requirements for walking areas of assembly spaces such as auditoriums. Include emergency lighting in group toilet rooms, shower rooms, locker rooms, mechanical rooms and electrical rooms.

- Illuminated exit signs shall be strategically placed where they can be seen from any position in corridors (both directions), gymnasiums, multipurpose rooms, cafeterias, auditoriums, media centers, and other assembly areas.  Where corridors have smoke doors, exit fixtures usually should be located over the doors on both sides of the wall.  LED (light-emitting diode) exit lighting fixtures should be used.

- Per NEC 700.16 Emergency lighting systems shall be designed so that failure of an individual element will not leave are served in complete darkness.  This is a particular concern with battery backed up fluorescents and exterior compact fluorescent fixtures.  Often the ballast only serves a single lamp. Verify with the manufacturer that this condition does not exist for the intended light fixture.

- Emergency lighting is not to be switched off unless a means is provided to automatically turn lights on upon loss of power.  This condition exists commonly in exit discharge applications with time clocks, auditoriums, and areas served by a generator. This can often be solved using a switch bypass device.

- Cafeterias, auditoriums, multipurpose rooms, gymnasiums, and other assembly areas shall have emergency illumination, as shall all interior spaces that exist without available natural light and that are occupied by students.  Un-switched night lights shall be provided in these same spaces.

- Where metal halide or high pressure sodium lighting is used, supplemental lighting should be used to provide illumination during momentary power outages. Metal halide fixtures, in particular, take an extended period of time to return to full illumination. Fluorescent lighting is recommended for the supplemental system, but some metal halide and high pressure sodium fixtures can accommodate quartz-type supplemental fixtures.

- Battery-powered exit and emergency illumination systems are recommended due, in part, to ease of maintenance. Single fixture or single circuit inverters can be useful for auditorium and exit discharge applications. On larger facilities, emergency generators may be more cost effective or the owner may have a preference for them.

## Lighting Retrofits

The following criteria is for one for one lighting retrofits that do not require the replacement of the ceiling or modify the location of the ceiling. If the layout is modified or the ceiling is replaced a full submittal of all trades would be required.

- Identify on the plans the quantity of each fixture that is to be replaced.

- Provide a fixture schedule identifying characteristics of the replacement fixtures (lens, reflector, ballast/driver, lumen output, method of control (dual ballast, step dimming, dimming etc..))

- Make sure that any fixtures with battery ballasts are replaced in kind. Make sure all fixtures connected to the emergency system remain connected and are separately wired as required by the NEC.

- Make sure all installation conditions are properly dealt with. (supports to structure, fire rating boxing, IC rating, wire guards, etc..)

- Provide criteria for light output. If fixtures are to replace fixtures with different light output then provide fixtures with different light output. See the end of this document for recommended lighting levels for each type of typical space.

## General Illumination

- Good lighting system design necessary to create a proper visual environment can result from close cooperation between design professionals and educators. Four major factors that must be considered in developing the design are levels of illumination; reflectance and ranges of reflectance; brightness and brightness ratios; and contrast.

- Recommended levels of illumination are provided later in this section. See also ANSI/IES RP3 (latest edition) *Guide for Educational Facilities Lighting*.

- The following is a typical procedure for the design of a lighting system.
    - Establish desired environment:
        - Brightness and brightness ratios
        - Colors and textures
        - Methods of control in spaces; zoned switching, automatic control, control systems and daylighting and daylight controls
    - Establish reference task and required illumination levels
        - Classrooms
        - Special purpose areas (labs; libraries; shops; etc.)
    - Establish general illumination system
        - Distribution characteristics and energy use of light sources
        - Coordinate with effect of task visibility
        - Coordinate with total environment
            - Characteristics of heat and noise production
            - Color acceptability
            - Special and aesthetic characteristics
    - Establish supplemental illumination (task lighting)
        - Chalk and marker boards
        - Special Tasks
        - Special Areas

    - Establish audiovisual requirements
    - Analyze economics (life-cycle cost analysis)
        - Capital expenses
        - Maintenance expenses
        - Electrical energy costs

- In addition to base ambient light levels, other control methods should be provided to uniformly reduce the lighting to a minimum of 50% illumination level. Refer to ANSI 90.1 – 2007 or the North Carolina State Building Code (Energy) for more specific requirements.

- Due to extensive use of smart boards and projectors, it is recommended that a separate zone of lights be provided near the primary wall, which can be shut off, to allow clear vision of audio visual systems.

- Due to the reduction of allowed wattages in spaces, electronic ballasts are expected for fluorescent fixtures and high efficiency electronic ballasts are recommended. Primary lamp types for troffers and linear fixtures should be T8 and T5 based on the application. To further reduce energy usage, consider lower wattage T8 lamps (30watt, 28watt and 25watt). Make sure that required light levels are maintained when lower wattage lamps are used. Whenever possible replace existing magnetic ballasts and T12 lamps.

- Outdoor lighting for security, walkways, and parking lots should provide adequate illumination for moving to and from buildings and to discourage vandalism. Acceptable sources for these type fixtures are Metal Halide, Compact Fluorescent, High Pressure Sodium and LED fixtures. Coordinate this choice with the owner's needs/desires and budget.

- Wiring and lighting athletics fields involve consideration of lighting intensities; fixture selection, arrangement, and quality; and safety of the installations (NEC and NESC). Underground distribution of 277/480 volt is recommended with metal halide fixtures. High voltage distribution by school systems is not recommended due to a general lack of adequate equipment and expertise.

- Incandescent lamps use five times the energy and power required for fluorescent or metal halide lamps and should only be used for specialty applications such as for stage lights. Consider replacing existing screw-in incandescent lamps with similar compact fluorescent. Mercury vapor lamps use twice the energy and power of metal halides and should not be used. Dimming can also be used on fluorescent, LED and metal halide fixtures (in limited applications). Self-extinguishing metal halide lamps (and mercury vapor, if used) shall be used to prevent ultraviolet radiation burns when broken.

- Motion detectors, or other electronic switching devices sensitive to the presence of people are recommended. System features (sensitivity, dual technology, delay settings) should be specified to properly suit the environment.

- Daylight control systems should be controlled by photo sensors to reduce inside lighting levels when natural lighting permits but allow full artificial illumination only when conditions warrant can be considered. Careful coordination must be given to the design of daylighting controls, to prevent reduction of lifetime for fluorescent, metal halide, and high pressure sodium lamps and to avoid frequent dimming/switching caused by a change in natural illumination.

- North Carolina General Statutes provide for public schools to contract for energy conservation measures for existing facilities only. School systems may contract for new lighting, heating, insulation, air conditioning and other energy conservation measures and use the resultant savings over a maximum period of eight years to pay the contractors.  For these types of projects and for all energy efficient designs the design should meet desired energy criteria but still provide adequate illumination levels per IES recommendations.  See “Recommended Lighting Systems, with Illumination Levels” which is included as part of this standard.

## Recommended Lighting Systems, with Illumination Levels

| INTERIOR LOCATIONS | Work Surface_Illumination in Maintained Foot-Candles** | | | TYPE OF LIGHTING FIXTURES (1) |
|---|---|---|---|---|
| | Task Area / Recommended fc | General Area Recommended fc | Weighted Average fc | |
| **Auditoriums** | | | | |
| Seating Area | 0%/na | 100%/20 | 20 | Fluorescent (Dimming or Multiple Switching) |
| Stage Set-Up | 0%/na | 100%/20 | 20 | Fluorescent |
| Concerts on Stage | 65%/50 | 35%/30 | 43 | Fluorescent |
| Drama with Accents | Variable | Variable | | Incandescent (Tracks with Dimming Equipment) |
| Lobby | 10%/25 | 90%/15 | 16 | |
| **Cafeterias** | | | | |
| Kitchen/Serving Area | 50%/75 | 50%/40 | 58 | Fluorescent |
| Dining Room | 50%/50 | 50%/30 | 40 | Fluorescent |
| Cashiers | 50%/75 | 50%/40 | 58 | Fluorescent (Task Lighting) |
| Dish Washing | 50%/75 | 50%/40 | 58 | Fluorescent (Listed for Wet Locations) |
| **Classrooms** | | | | |
| General | 65%/50 | 35%/30 | 43 | Fluorescent |
| Art | 65%/50 | 35%/30 | 43 | Fluorescent |
| Computer | 65%/50 | 35%/30 | 43 | Fluorescent |
| Drafting | 65%/50 | 35%/30 | 43 | Fluorescent |
| Home Economics | 65%/50 | 35%/30 | 43 | Fluorescent |
| Computer Areas in Classrooms | 65%/50 | 35%/30 | 43 | Fluorescent indirect or parabolic lens |
| General Laboratories | 30%/75 | 70%/50 | 57.5 | Fluorescent |
| Speech/Lip-reading | 65%/50 | 35%/30 | 43 | Fluorescent |
| Music | 65%/50 | 35%/30 | 43 | Fluorescent |
| Sewing | 50%/100 | 50%/30 | 65 | Fluorescent (Task Lighting) |
| Shops | 25%/75 | 75%30 | 41 | Fluorescent (Higher Levels Can be Used for Detail Works) |
| Typing | 65%/50 | 35%/30 | 43 | Fluorescent indirect or parabolic lens |
| **Corridors and Stairwells** | | | | |
| (Use Remote or Keyed Switching) | | | | |
| Corridors | 0%/ na | 100%/15 | 15 | Fluorescent |
| Stairways | 0%/na | 100%/20 | 20 | Fluorescent |
| Trophy Cases | 100%/15 | 0%/ na | 15 | Compact Fluorescent |
| **Gymnasiums - Use Multiple Switching to Obtain Various Levels** | | | | |
| Competition between Schools | 0%/na | 100%/75 | 75 | Metal Halide, Fluorescent |
| Physical Education | 0%/na | 100%/50 | 50 | Metal Halide, Fluorescent |
| Lockers and Showers | 100%/40 | 0%/na | 40 | Fluorescent Listed for Wet locations) |
| Elementary (Multipurpose) | 0%/0 | 100%/30 | 30 | Metal Halide or Fluorescent |
| Mechanical, Electrical & Boiler Rooms | 0%/na | 100%/30 | 30 | Fluorescent (Industrial Fixtures) or Incandescent if on while "Temporarily" Occupied |

| INTERIOR LOCATIONS | Work Surface Maintained Illumination in Foot-Candles** | | | TYPE OF LIGHTING FIXTURES (1) |
|---|---|---|---|---|
| | Task Area / Recommended fc | General Area / Recommended fc | Weighted Average fc | |
| Media Centers | | | | |
| Reading Room, Check In/Out | 90%/50 | 10%/30 | 48 | Fluorescent |
| Book Stacks, Magazine Racks | 80%/50 | 20%/20 | 44 | Fluorescent |
| Office Areas | 80%/50 | 20%/30 | 46 | Fluorescent |
| Storage | 100%/20 | 0%/na | 20 | Fluorescent |
| AV Repair | 20%/50 | 80%/20 | 26 | Fluorescent (Task Lighting) |
| Offices | | | | |
| General Office Work | 80%/50 | 20%/30 | 46 | Fluorescent |
| Close Work | 50%/100 | 50%/30 | 65 | Fluorescent (Task Lighting) |
| Teacher Workroom | 80%/50 | 20%/30 | 46 | Fluorescent |
| Conference Room | 50%/50 | 50%/30 | 40 | Fluorescent |
| Storage Rooms, Pipe Chases, | | | | |
| Attics, Crawl Spaces | 100%/20 | 0%/na | 20 | Fluorescent (or Incandescent if on “Temporarily” While Occupied) |
| Swimming Pools | 0%/na | 100%/50 | 50 | Metal Halide or Fluorescent (Listed for Wet Location) |
| Washrooms/Group Toilets | 10%/50 | 90%/20 | 23 | Fluorescent (Use Remote or Keyed Switching) |
| Washrooms/Faculty Toilets | 10%/50 | 90%/20 | 23 | Fluorescent |

**(1) LED Fixtures can be considered for many applications but may add additional cost. Consider having an alternate for LED to allow financial flexibility.**

## Exterior Locations (All Fixtures shall be listed for Wet Locations and Outdoor Use)

| EXTERIOR LOCATIONS | Work Surface Maintained Illumination in Foot-Candles* | | TYPE OF LIGHTING FIXTURES |
|---|---|---|---|
| | Minimum | Maximum | |
| **Building Exterior** | | | |
| (For Security Purposes) | 1 | 1 1/2 | High Pressure Sodium, Metal Halide, LED |
| *Parking Lots and Walkways* | 1 | 1 1/2 | High Pressure Sodium, Metal Halide, LED (Consider solar LED. Compact Fluorescent can be used for walkways) |
| **Sports Complexes*** ** | | | |
| Soccer/Football Stadium Badminton/Volley Ball/ | 30 | 50 | Metal Halide |
| Tennis Courts | 20 | 30 | Metal Halide |
| Baseball/Softball<br>Outfield<br>Infield | 20<br>30 | 30<br>50 | Metal Halide<br>Metal Halide |
| Separate Running Tracks (Not a Part of a Football or Baseball Stadium) | 20 | 20 | Metal Halide |

* Based on IESNA Recommendations

***Refer to NCHSAA for state play-off lighting standards.

**Based on NEIS LPD (Lighting Power Density) Models

## Fire Alarm; Smoke and Heat Detection Systems

- Manual fire alarm systems are required for all new school buildings over 5000 square feet and for additions and major renovations, regardless of whether existing facilities have fire alarm systems. Automatic fire alarm systems are acceptable alternatives (North Carolina State Building Code, Section 907).

- Automatic smoke detectors are required for specific locations; (smoke doors, within 15 feet of a Fire Alarm panel, elevator lobbies) as required by the North Carolina State Building Code.

- Rate-of-rise heat detectors should be installed in boiler and furnace rooms and smoke detectors should be installed in rooms in which paper products and /or other flammable materials are stored.

- Alarm horns/strobe lights shall be located in all public and common areas of the building to satisfy ADA and fire safety code requirements. See North Carolina State Building Code 907.5.C for specific requirements. Outside alarms are recommended to alert persons not to enter and to alert neighbors when facilities are unoccupied. Locate in areas where students congregate on the exterior of the building.

- All smoke and heat detectors shall be tied in to the fire alarm system and shall activate all alarms.

- Duct detectors as a minimum per North Carolina State Building Code (Mechanical) Section 606.4.1 shall provide a supervisory signal. Verify with the local code official if duct smoke detectors will be required to provide an alarm signal.

- As part of the design documents provide a Fire Alarm system riser/block diagram that clearly defines the scope of the fire alarm work for the project. It should be clear on the riser diagram what type of system is proposed (addressable or conventional), the number of loops, zones and each type of device and auxiliary equipment that is intended to be connected to the system. When connecting to an existing system the diagram shall identify the manufacturer of the existing system, and how the new devices are to be connected and controlled by the existing system.

- The plans should identify every device that is to be connected to the system and the location of all Panels (new or existing), terminal cabinets, power supplies and auxiliary devices. Layout shall be consistent among all proposed area types.

- When connecting to an existing system, the designer is to verify the capacity, age and capability of the existing system and shall include in their design all of the necessary components to allow the system to accept the proposed devices, and provide direction concerning how the new devices are to be controlled by the existing system. If the existing system does not have adequate capacity or parts are no longer commercially available, replace the system.

- The plans should provide all direction necessary to define the intended system to allow the contractor to submit Fire Alarm Drawings meeting the criteria identified on North Carolina State Building Code, Section 907.1.2 including but not limited to battery requirements, intended candela ratings, wire size, inclusion of surge protective devices and isolation modules.

- Plans should include a system operational matrix.

Technology Systems

- Scope of design for technology systems (Tel/Data, Public Address, Intercom, MATV and CATV, Security {Motion Detection, CCTV/Camera, Card Access], and Theatrical Sound/Lighting) shall be clearly defined on the plans. The design of each system shall include a riser/block diagram that outlines the scope of work for each system. The riser shall provide clear direction of what portion of the system is to be provided by the electrical contractor, any portions to be provided by other contractors and what portion is to be provided by the owner (self-performed or outside contract).

- When connecting to an existing system, the designer is to verify the capacity, age and capability of the existing system and shall include in their design all of the necessary components to allow the system to accept the proposed devices, and provide direction concerning how the new devices are to be controlled by the existing system. If the existing system does not have adequate capacity or parts are no longer commercially available, replace the system.

- The plans should locate and identify every type of device that is to be provided and the plans/specifications should identify the quality and characteristics of the devices, cabling, connectors and equipment.

- Provide adequate space, environmental conditions and adequate power for intended equipment.  The State of North Carolina STS-1000 Guidelines is a good resource for direction and criteria for technology systems.

- Include Surge protection for any cabling leaving the building footprint.

- Refer to NEC Article 800.25 for direction about abandoned cable.

- Sound systems shall provide school-wide sound distribution from a single location and shall also be designed for two-way communication. In the initial design, it is recommended that the degree of sophistication should be consistent with its intended use

- Timed Audible Class change systems are recommended for orderly control of class periods within the school day.  Systems and equipment should be kept as simple as practical to minimize operational and maintenance costs.

- Complex clock systems can be expensive to purchase and maintain. Clocks that operate directly from 120V receptacles or batteries are recommended. Other more expensive alternatives are the use of wireless synchronized clocks, or the use of clocks connected to an integrated intercom system. The use of televisions solely as a visible source of the clock system should be avoided.