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ABSTRACT

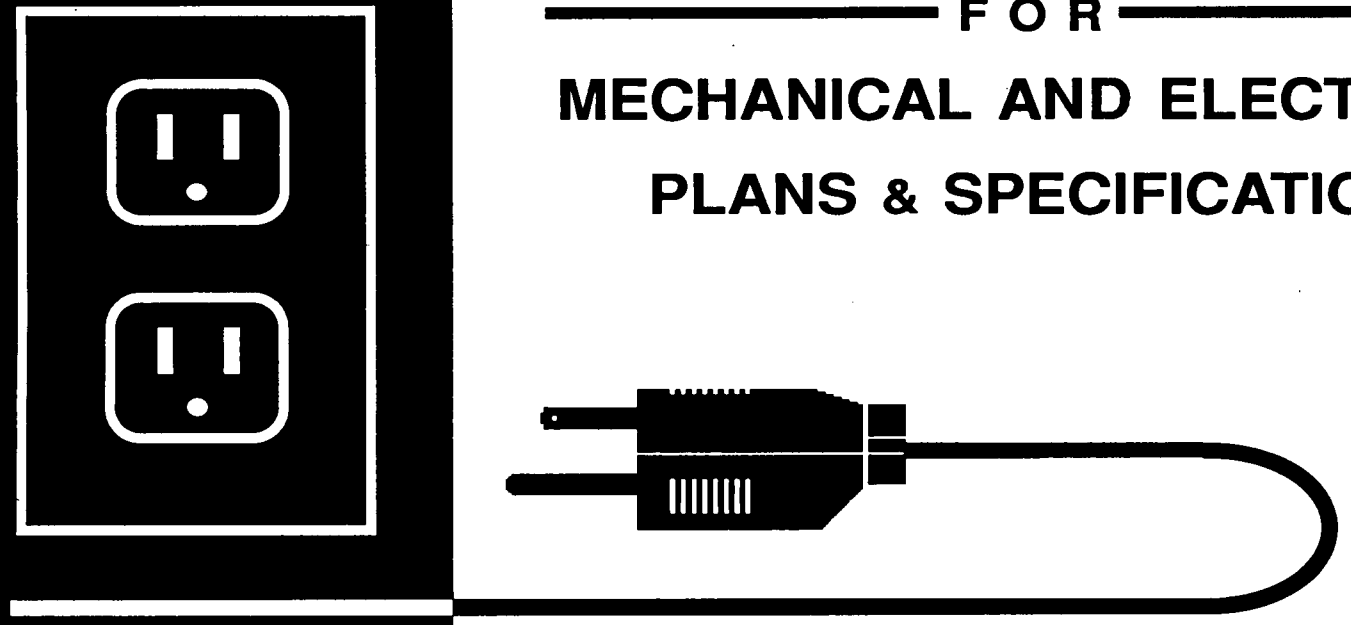
This is the fifth revision of the Minimum Check List since its origin in 1960 by North Carolina's School Planning. The checklist was developed to serve as a means of communication between school agencies and design professionals and has been widely used in the development and review of mechanical and electrical plans and specifications by engineers, architects, and superintendents in planning public school facilities. The checklist has three primary sections: plumbing systems, mechanical systems, and electrical and lighting systems. Specific guidelines on drainage and waste, fittings, fixtures, water supply, gas systems, stack and breeching, boilers, oil burners, piping, heaters, controls, heating systems, air conditioning, service entrance feeders, branch circuits, and alarm systems are provided. Diagrams showing grounding methods, a typical electrical summary, and recommended lighting systems with illumination levels appear at the end. (RJM)

E1-

MINIMUM CHECK LIST

FOR

MECHANICAL AND ELECTRICAL PLANS & SPECIFICATIONS



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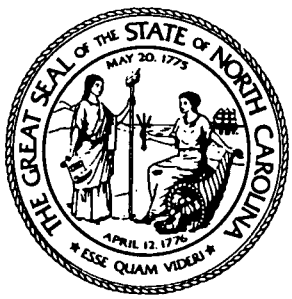

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BOB ETHERIDGE
State Superintendent

June 29, 1992

MEMORANDUM

TO: Engineers, Architects, Educators and Other Interested Parties

FROM: School Planning, Division of School Facility Services
North Carolina Department of Public Instruction

SUBJECT: "Minimum Check List for Mechanical and Electrical Plans and Specifications"

Numerous changes have been made in the mechanical and electrical fields since the previous publication of the "Minimum Check List". The revision attached is an effort to address those changes. The following focus on several which require special attention.

PLUMBING PLANS AND SPECIFICATIONS

1. The major domestic hot water demand in public schools is the kitchen equipment. Generally, this is a 140°F requirement. Such heaters should supply kitchen equipment only and should be fossil-fuel fired.

2. With the exception of kitchen and athletic facilities, all other hot water may be electrically heated as the demand is not that great. Separate generation equipment should be provided for low temperature requirements (lavatories and showers) to eliminate all chances of scalding.

3. Always recirculate from the most distant fixture or fixture group. However, the smallest recirculation pump available will usually suffice for any application.

4. Plumbing fixture trim should be completely specified as well as fixtures. Generally, drafting schedules are incomplete. What is not specified usually gets installed at lower quality.

5. Place isolation valves as if you had to pay for them and service the fixtures in the future.

6. Do not use aquastats or mixing valves. Instruct draftsmen to delete them from "standard" details.

HVA/C PLANS AND SPECIFICATIONS

1. Provide access to all HVA/C equipment as if you were to be servicing it.

2. Hydronic systems installed now will give system fuel and equipment flexibility in the future.

ELECTRICAL PLANS AND SPECIFICATIONS

1. Short Circuit (Fault) Currents and Withstand Ratings

   As a result of the increase in capacity of the National Electrical Power System grid, and larger and air conditioned schools requiring more electric power capacity, the short circuit currents available at the service entrance conductors and panels are gradually getting larger. The available short circuit current (or KVA) should be placed on the riser diagram so an awareness is made to electrical engineers, that will remind them to provide proper coordination of the electrical system within the school buildings for both new and remodeled projects, with emphasis on older buildings.

2. Non-linear Loads

   Numerous computers, ballasts (electromagnetic and electronic) for lighting fixtures, adjustable frequency motor drives and other electronic equipment will be installed in new and existing schools. The non-linear loads and harmonics are of considerable concern in these installations. Transformers designed for non-linear loads and oversized neutrals for feeders and branch circuits should be considered in these applications.

3. Transient and Surge Voltages

   Electronic equipment is very sensitive, and protection is generally necessary for lightning, power company switching and generation surges and disturbances created within the school building electrical system. Transient and surge protection can be provided at:

   a. The service entrance.

   b. In the panelboards serving the electronic equipment.

   c. In the receptacles serving the electronic equipment (if the equipment does not have built-in protection).

   One, a combination of the three or all three may be needed. Use your professional knowledge and judgement. Protection is required for telephone and data conductors which go from building to building or across town.

4. Lighting Systems

   Recommended lighting levels are now indicated with a minimum and maximum foot candle range. The type of lighting fixtures which are acceptable are included for each particular area. Incandescents and mercury vapor are "out" except where noted. The use of electronic switches are encouraged to disconnect lighting circuits in unoccupied rooms.

5. Americans with Disabilities Act (ADA)

   Particular attention is directed to sound systems, fire alarm systems, exit and emergency lighting and telephone accessibility. Corrective measures to assist the sight and hearing impaired are addressed in the ADA. Hearing aids connected to telephones and auditorium/gymnasium/multi-purpose room sound systems, additional flashing strobe lights for restrooms, strategic placement of all the audible/visual devices in fire alarm systems and sufficient lighting for emergency situations and proper directions for exits shall be provided.

RCH/APW/ts

MINIMUM CHECK LIST

FOR MECHANICAL AND ELECTRICAL PLANS AND SPECIFICATIONS

CONTENTS

FOREWORD i
PREFACE ii
PLUMBING SYSTEMS 1
MECHANICAL SYSTEMS 8
ELECTRICAL AND LIGHTING SYSTEMS 18
DIAGRAM SHOWING GROUNDING METHODS - SINGLE BUILDING 29
DIAGRAM SHOWING GROUNDING METHODS - MULTIPLE BUILDINGS 30
TYPICAL ELECTRICAL SUMMARY 31
RECOMMENDED LIGHTING SYSTEMS WITH ILLUMINATION LEVELS 32

ABBREVIATIONS

ADA ..... AMERICANS WITH DISABILITIES ACT

AGA ..... AMERICAN GAS ASSOCIATION

DEM ..... DIVISION OF ENVIRONMENTAL MANAGEMENT

DEHNR ... DEPARTMENT OF ENVIRONMENT HEALTH & NATURAL RESOURSES

IBR ..... INSTITUTE OF BOILER AND RADIATOR MANUFACTURERS

IES ..... ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA

NFPA ..... NATIONAL FIRE PROTECTION ASSOCIATION

NEC ..... NATIONAL ELECTRICAL CODE

NSF ..... NATIONAL SANITATION FOUNDATION

NCBRR .... N. C. BOILER RULES AND REGULATIONS

NCGS ..... N. C. GENERAL STATUTES

NCSBC .... N. C. STATE BUILDING CODE

SBI ..... STEEL BOILER INSTITUTE

UL ..... UNDERWRITERS LABORATORIES, INC.

FOREWORD

Students, teachers, parents, administrators, architects and engineers are very much aware of the importance of the physical environment to the educational process. Much progress has been made toward improving the environment, primarily the result of considerable effort on the part of educators and those engineers and architects involved in the design of public school facilities. At the same time, a concerted effort has been made to improve the design and installation of the total mechanical and electrical systems, all to the best interests of the students and the school systems. This, too, has been a joint effort on the part of educators, engineers and architects. For the most part, the results have been very gratifying.

This Minimum Check List was developed by School Planning to serve as a means of communication between school agencies and the design professions. It is and should remain a "minimum" check list that includes concise, pertinent, and well chosen comments without being voluminous. Such is the intention of this revision. Please note that the Minimum Check List represents the thinking of a representative cross section of the design professions.

This publication is one of many that have been prepared and distributed by the Department of Public Instruction as an aid to the ever changing process of planning and developing public education facilities.

Bob Etheridge
State Superintendent
North Carolina Department of Public Instruction

Charles H. Weaver
Assistant State Superintendent
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PREFACE

This is the fifth revision of the Minimum Check List since its origin in 1960 by School Planning. It has been widely used in the development and review of mechanical and electrical plans and specifications by engineers, architects and superintendents in planning public school facilities. School Planning is pleased to make available this revision in the hope that it will continue to be a useful publication.

Appreciation is expressed to the following individuals for their assistance in preparing this revision:

Private Practicing Engineers:
W. C. Canaday, Hickory
B. A. Hamrick, Jr., Charlotte
H. G. Hoomani, Raleigh
D. E. Rouse, Wilmington

Representing State of N. C. Agencies:
J. A. Barringer, Dept. of Insurance
A. P. Winslow, School Planning
R. C. Harrell, School Planning

In using this check list, the following interpretations should be kept in mind:

- Items using the term "shall" are mandatory because of law, code or regulation.
- Items using the term "should" are those which experience has taught are most practical and desirable. Any deviation should be supported by adequate information and reasoning and should be cleared with School Planning in the early stages of the design process.
- Other items are included as good practices about which professional people may not entirely agree.

Karen S. Gulledge

Dr. Karen S. Gulledge
Chief Consultant, School Planning
North Carolina Department of Public Instruction
July 1992

PLUMBING SYSTEMS

DRAINAGE, WASTES AND VENTS

- Floor drains shall be installed in all toilet rooms containing more than one water closet, and at all points where water heaters are located. Undercounter water heaters are not necessarily included, but relief valve discharges shall be disposed of properly. Infrequently used floor drains should have traps resealed by waste from clear water fixtures. Provisions should be made for resealing traps of floor drains located in rooms being used as return air plenums. It is recommended that these drains be four inch minimum size, and that sediment strainers be used. Drains in all areas should be not less than three inch size.

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

- Floor drains shall be provided for boiler rooms, and for mechanical equipment rooms containing any equipment using steam or water, or incorporating cooling coils.

- The plumbing plans shall bear the seal of the engineer who is responsible for their design, and IS BY LAW REQUIRED to inspect and issue a "Certificate of Compliance" upon completion of the project (NCGS 133-1.1).

- Acid resisting waste lines should be considered for chemistry laboratories in high schools, and perhaps some other special uses such as the chemistry instructor's table in a middle school. They are not considered necessary for other normal laboratory areas. Corrosion resistant traps are required on all fixtures in chemistry classrooms, and may be used if desired in other laboratories such as physics and biology.

- P-traps to the wall, or located below floor, are preferred to S-traps to floor. Plaster and/or interceptor traps are usually needed for work sinks in areas such as art classrooms.

- Vent pipe flashings, at the roof, should be made in two pieces. One of these should be a cap which slides down over top of the pipe, and sufficiently overlaps the base flashing. Copper or lead is preferred.

- Screens, to protect against gravel, rocks, etc., are recommended for installation on these flashings.

- Reference is made to the sizes of vent piping at the point where it passes through the roof. It is recommended that two inches be a minimum size.

- Cleanouts placed in horizontal pipe runs should be fabricated using longsweep one quarter bends or fittings providing one eighth turn. Standard one quarter bends should never be used.

- In clay (V.C.) pipe sewer lines, cast iron fittings should be provided at the bases of cleanouts to prevent breaking with end of the sewer rod.

- Roof drainage shall be designed in accordance with requirements of the NCSBC, Plumbing, Chapter XV (as minimum).
- The actual installation of roof drains and flashing, for interior roof drain systems, should be made by the general contractor. Piping for such systems should be by the plumbing contractor.
- Reference is made to the NCSBC, Volume 1-C entitled "Making Buildings and Facilities Accessible to and Usable by the Physically Handicapped". Appropriate provisions of this section are applicable to plumbing systems in public schools.
- Water closets, urinals, lavatories and drinking fountains or water coolers must be considered for the handicapped.

FITTINGS

- All hose bibbs should have minimum 18" clearance underneath.
- A hose bibb with a removable handle or a key operated lock shield should be installed in any toilet room having a floor drain.
- Each fixture should have an individual water supply cutoff valve.
- Flush valves must be equipped with vacuum breakers (NCSBC, Plumbing, Chapter XII.).
- Use freeze proof hose bibbs where applicable; these should be key operated.
- All hose bibbs, including wall hydrants and any outlets with hose threads, shall have backflow prevention devices installed (NCSBC, Plumbing, Chapter XII). For exterior installations, care must be taken to prevent freezing.
- Lavatory waste fittings should be cast type, as opposed to tube construction.

FIXTURES

- Lavatories should be acid resisting, and have rigid supplies. Strainers, (beehive or grid type are suggested), and not pop-ups or plugs, should be used in lavatory wastes in public toilets and restrooms.
- Elongated bowls and open front seats, without covers, for water closets are required by Code (NCSBC, Plumbing, Section 906.1 and 907.1). For male toilets, the recommendation is that water closet seats incorporate the self-raising spring hinge or the self-sustaining friction hinge with check features.
- A lavatory shall be located in the kitchen area for handwashing. This lavatory shall have a mixing faucet supply fitting.

2

- A service sink or a receptor should be located within the confines of the kitchen area.
- Standard, single purpose fixtures should be used where waterworks and plumbing are concerned; i.e., a handwashing lavatory should not be combined with a drinking fountain, a mop sink should not be combined with a handwashing lavatory, nor should one be substituted for the other.
- Drinking fountains outside a building shall be frost proof. All wastes from these should be carried to dry wells or storm drains. Dry wells should 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 in counter tops.
- Supplies (pipe, valves and fittings) that are concealed, such as for counter top sinks, do not need to be the rigid type, and need not be plated.
- Gymnasium dressing rooms should have drinking fountains. These should not be water coolers.
- Wall hung type urinals with shields are recommended.
- NCSBC, Plumbing, Section 910.3 requires a maximum flow rate of 3gpm for a shower head.

WATER SUPPLY

(see Sections 7 and 8 of the NCBRR and Chapter XII of the NCSBC, Plumbing)

- Wells must be located away from possible sources of contamination, properly protected, and well sites must be approved by a representative of the Division of Health Services, DEHNR.
- At school sites where well water systems are planned, owners, architects and engineers are urged and encouraged to consult the state DEHNR, Division of Environmental Management for geological information.
- Plans shall show the location of the well, and complete details of the well supply system including well, pump, pump house, piping and storage tank. If the storage tank is pressurized and exceeds 120 gallons nominal water containing capacity, it must be of ASME construction and registered with the National Board (refer to NCBRR). When an elevated tank is installed, a fire hydrant shall be properly located on the site, or that a hose connection be provided on the standpipe, or both. For any kind of on-site water supply, reasonable and appropriate fire protection equipment should be installed. When new well supply systems are used, provisions for continuous chlorination are strongly recommended.
- When water is obtained from a public system, plans shall show location of the water supply connection, and size of the water meter. Pressure reducing stations should be utilized where supply pressure exceeds 80 psig.

3

- Dishwashing and showering are the two factors to consider in sizing water heating equipment. Such equipment must be placed where components can be easily maintained. Kitchen and shower hot water should be generated and controlled separately.
- Tempering valves, if utilized, should be placed at point of use. Generating and storing shower water at nonscalding temperatures is recommended.
- 180 degree water heaters should carry the NSF label, or equal (NSF Standard No.5).
- Sanitizing hot water from water heater to dishwasher booster heater should be recirculated by pumping in order to maintain maximum temperature at the booster.
- Water heaters and/or storage tanks must have safety valves that are sized and installed in accordance with requirements of the NCBRR.
- Water heaters incorporating the use of dip tubes must conform to the requirements of the NCBRR.
- All hot water storage equipment should have tanks equipped to prevent interior corrosion.
- For electric water heaters of all types, the engineer must be careful to comply with (1) all the requirements of Article 422-14 in the NEC; and (2) NCBRR requirements for the UL label. Control voltage should always be volts to ground such as 120 volts or 277 volts. All water heaters should be controlled on an energy management system.
- Circulators for domestic hot water use should be all bronze construction. Control should be by time clock as well as temperature. All starters for circulators (pumps) using three-phase current must incorporate overload protection for all three phases (NEC Article 430-37).
- All water supply systems shall be disinfected before being placed in service. (NCSBC, Plumbing, Section 1207).
- The engineer shall designate on a plumbing drawing the source of water supply.
- Domestic water piping should not be routed below slab-on-grade construction.

4

SEWAGE DISPOSAL SYSTEMS

- Locations and principal elevations of connections to public sewer systems shall be shown on plans (NCGS 130-13).
- When an on-site sewage treatment plant, or addition to an existing plant, is required and planned, the following considerations are applicable:

- Application shall be made to DEHNR for plants that discharge to the land surface, to surface waters; or for plants that discharge to ground absorption systems.
- Both the site (new or existing) and the proposed plant and system (new or existing) shall be approved by this agency.
- This agency must be consulted prior to procuring a site where on-site sewage treatment and/or disposal is contemplated.
- Plans and specifications for the proposed sewage treatment plant, or addition to existing, should be prepared in accordance with DEHNR recommendations, and shall be submitted to them for approval.
- DEHNR approval for a project must be made before the State Superintendent of Public Instruction issues the certificate of approval.
- Plans for sewage treatment plants shall include complete details and elevations of all units and appurtenances, including profile from buildings to final point of waste disposition.
- A complete summary of plumbing loads, in fixture units, shall be shown on the plans.
- For aeration type sewage plants (on-site): (1) a suitable fence (which should include barbed wire at the top) is mandatory to exclude children from this dangerous area, and (2) the manufacturer's standard covering for the entire tank is recommended.
- All plans, whether for new work or addition to existing, must indicate clearly whether sewage disposal is to a municipal system or to an on-site system.
- When sewage disposal will be to a municipal system, check should be made to assure that the system can accept the additional load.

GAS SYSTEMS

- All gas systems, whether for LP or natural gas, must conform strictly to the requirements of "NFPA-54, National Fuel Gas Code". Applicable also is Volume III of the NCSBC.
- In particular, the two areas in Section 54 that are of most concern are (1) the kinds and types of pipes that are acceptable for gas; and (2) the allowable methods for installing pipe with respect to routing, placement, special treatments and valving arrangements.
- School Planning recommends that metallic pipe, but not tubing, always be used for gas systems. Welded joints, for larger sizes, are considered good practice.

5

- All gas piping should be specified to have a 100 psi air test with soap solution applied to all joints.
- In all localities where applicable, the engineer should specify that a permit for installation of gas appliances must be obtained, and local inspection of the work must be requested.
- In locating gas-fired water heaters, in either new or existing facilities, the engineer must assure that there will be adequate air for combustion and proper ventilation for the space.
- Gas piping to laboratory case work should have a shutoff valve installed in a lockable panel or at the instructor's table, which is lockable.

GREASE TRAPS

- Exterior grease traps shall be installed. Applicable directions and instructions should be closely followed. A standard size, concrete septic tank is recommended, with capacity to be 500 gallons minimum.
- Interior grease traps are not recommended and shall not be used.

Plumbing Fixture Recommendations

- Locate toilet facilites for students and teachers so that no person will have to travel more than 200 ft. for access.
- Minimum facilities shall be provided in accordance with revisions to table 922.2 of Vol. II, NCSBC approved December 1990.

	WATER CLOSETS		URINALS	LAVATORIES
	M	F	M	
K -9	1 per 60	1 per 25	1per 45	1 per 60
10-12	1 per 100	1 per 25	1 per 45	1 per 100

- Provide one shower for each four persons in P.E. at time of largest class.

MOUNTING HEIGHTS (RIM)

FIXTURE AND APPLICATION	STANDARD	ACCESSIBLE TO THE DISABLED
WATER CLOSETS		
Grades Kindergarten through Three	15"	15"
Grades Four through Six	15"	15"
Junior and Senior High, Seven through Twelve	15"	17"-19"
URINALS		
Grades Kindergarten through Three	14"-17"	14"
Grades Four through Six	20"	14"
Junior High, Seven through Nine	22"	17"
Senior High, Ten through Twelve	24"	17"
LAVATORIES		
Grades Kindergarten and One	24"	28" (24" MIN. KNEE SPACE)
Grades Two through Six	27"	30"
Junior and Senior High, Seven through Twelve	31"	34"
DRINKING FOUNTAINS		
Grades Kindergarten through Three	24"	30"
Grades Four through Six	28"	30"
Junior and Senior High, Seven through Twelve	34"	34"
SHOWERS (SEE NOTES BELOW)		
Elementary Boys and Girls	50"-56"	66" FIXED & 48" FLEXIBLE
Junior High Boys, Seven through Nine	72"	74" FIXED & 60" FLEXIBLE
Junior High Girls, Seven through Nine	60"-66"	74" FIXED & 60" FLEXIBLE
Senior High Boys, Ten through Twelve	72"	74" FIXED & 60" FLEXIBLE
Senior High Girls, Ten through Twelve	66"	74" FIXED & 60" FLEXIBLE

MECHANICAL SYSTEMS

GENERAL

- The State Department of Labor boiler and tank operating certificates are required for all boilers and certain water heaters.
- Adequate free combustion and ventilation air shall be provided in the boiler room (NCBRR, Section 0400, Rule 0413).
- Motor overload protection must be as specified by the NEC. For three-phase motors, protection is necessary for all three phases (NEC 430-37).
- Gutters are prohibited on range hoods. The range hood should be mounted so that there is a minimum of six feet and six inches and a maximum of seven feet clearance from the floor, and it should be constructed so that there is at least 12 inches vertical rise on the inside before the hood starts to taper. Range hoods should cover the entire area of the cooking equipment, and surround such area by at least six inches. Capacity of the range hood fan should be approximately 100 cfm per square foot of hood area. A two-speed fan is recommended. It is recommended that ventilation air be discharged straight up all the way; if this is not done, appropriate cleanout doors should be provided. Automatic fire extinguishing equipment must be installed in kitchen range hoods. (NCSBC, Volume III, Section 308).
- Adequate quantities of makeup air should be provided for all exhaust fans. Filtering and tempering air should be considered where this is desirable. Peripheral makeup type designs which use untempered air may be used.
- Engineers should size all valves on the plans if they are other than full pipe size.
- A complete heating and cooling summary shall be shown on the plans, either all or in part as is appropriate for a given school, as follows:
    - The new load.
    - The existing load; where this information is not available, the owner should make arrangements to provide it either by the design consultant or some other means.
    - The capacity provided for known future expansion.
    - The spare capacity provided if this is different.
    - The domestic hot water load where applicable.
    - The net SBI or IBR capacity of the boiler or boilers, where applicable.

8

- Heating and cooling design conditions shall be stated on the plans.
- The mechanical plans shall bear the seal of the engineer who is responsible for the design, and IS BY LAW REQUIRED to inspect and issue a Certificate of Compliance upon completion of the project (NCGS 133-1.1).
- Boiler room floors should be at or above grade elevation.
- The engineer should select all "running" equipment with respect to the noise and vibration factor, especially that which is to be used in or adjacent to occupied spaces.
- Engineers shall specify and be certain that properly balanced air and water systems are obtained.
- A complete orientation of the HVAC system should be provided for the maintenance staff by the engineer or the manufacturer's representatives.
- Piping system cleaning treatment and placing in service should be completely specified.
- As built drawings should be provided to the owner. However, this service is not usually covered in the standard AIA contract and will have to be added.
- Sufficient spaces must be provided for all HVAC equipment so that proper clearances for maintenance service and filter changes can be accomplished. This is a requirement for all electrically operated equipment (see NEC 110-16, 17).
- When HVAC equipment is located outside, it should be enclosed and protected from damage from vandals and prevent unqualified persons from access, chain link fences and brick walls with lockable gates are examples.

STACK AND BREECHING

- Stack
    - There should be a hinged cleanout door for the chimney.
    - A flue lining is required (NCSBC, Section 1002). Coordinate with the architect.
    - A precast flue thimble or fire brick lining is needed where the breeching enters the chimney. Coordinate with the architect.
    - Connections at the thimble, breeching and chimney must be airtight for efficient operation.
    - For coal fuel and on new work, the use of induced draft fans is discouraged. In all cases, chimneys should be of sufficient heights to effect proper smoke abatement.

- When used, an induced draft fan should be supported independently of the breeching, have an expansion joint between it and the breeching, and should not obstruct normal access to the boiler.

- When metal chimneys are specified, as they might be for oil- or gas-fired equipment, the provisions of the NFC, Volume 4, NFPA 211 shall apply. The materials used and the establishment of proper clearances are of considerable importance.

• Breeching

  - The breeching should be supported independently of the boiler, and should be insulated for oil and coal fired installations.
  - Enough cleanouts, properly located, should be provided to promote easy, periodic cleaning.
  - A barometric damper should be used where applicable.
  - In multiple boiler installations, a locking type damper should be installed in each separate boiler breeching.

BOILERS

- At least three feet clearance is required (four feet is recommended) on top of low pressure boilers (NCBRR, Section 0400, Rule 0409) Four feet clearance is recommended on the sides as a minimum and from all attached pipes, gauges, controls, etc.

- Low pressure boilers with manholes should have at least five feet ceiling clearance.

- The ceiling clearance is five feet for high pressure boilers.

- The safety and/or relief valve capacity shall be specified.

- For tube removal and cleaning, steel boilers shall have minimum clearance of the length of the longest tube, plus 12 inches, at the front.

- Cast iron boilers should have sufficient clearance for cleaning and firing. This is normally the length of the boiler plus 12 inches.

- When sections are added to a cast iron boiler, the name plate and safety valve must be changed to comply with the new rating (NCBRR, Paragraph 2. V, Heating Boilers).

- Boiler Ratings

  - The SBI net rating should be shown for a steel boiler. Boiler selection should be made with respect to load, piping and pickup.

- The IBR net rating for a cast iron boiler should be specified.
- Where catalogues show only gross boiler ratings, care should be taken to determine the true net ratings, and proper selection should be made with respect to both the direct connected load and necessary pickup and piping losses (as applicable to schools).
- Safety valve and relief valve discharges should be installed in accordance with the NCBRR.
- The discharge line from the safety and/or relief valve shall be supported other than by the valve itself.
- Use copper wire to secure the insulation to the boiler unless insulation studs are used.
- Do not cover manholes, rodholes, name plate or ASME stamping on the boiler.
- The boiler bottom blowdown valve or valves, and piping, must be sized and arranged in accordance with requirements of the NCBRR, Paragraph 2. VII, Installation requirements.
- The return piping connection at the rear of the boiler should be made to either the center tap or to the center of a header connecting the two outside taps in order to provide even water flow into and through the boiler.
- Boiler piping, as installed, should not restrict the use of the smoke hood cleanout door, manhole openings, and plugged openings.
- A minimum of one brick course or three inch thick concrete base should be installed under a boiler and its firing device to prevent corrosion.
- Cross-type fitting should be used on steam boiler piping at water columns, water feeders and LW cutoffs for cleaning purposes.
- When specifying steam boilers, engineers should be very careful to properly evaluate the steam and water capacities (volumes) of the boilers in relation to the system served, and in relation to the kind of firing to be applied (gas, for example). Too little capacity results in some severe problems such as difficulty with holding the water line. The method of feedwater control becomes very important, and this should be properly designed and shown in detail on the plans. Each steam boiler application should be fully engineered to suit the system it will serve. Heating boiler design should incorporate a degree of spare boiler capacity without standby equipment. Where budget will permit, two boilers sized at 60 per cent each are recommended.

OIL BURNERS AND OIL STORAGE TANKS

- 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.

- Oil burner controls.
    - A cadmium cell relay is satisfactory for approximately 3gph and lower firing rates.
    - An electronic, program type primary control should be used for a firing rate greater than 3gph. In addition to safety cutout, this would provide prepurge and postpurge of the boiler; purging should definitely be provided.
- Oil storage tank capacity should be relative to the size of the heating plant, and to local service and delivery conditions. Normally a 10,000 gallon tank, minimum capacity, is required to obtain lowest fuel oil cost through central purchasing.
- The tank should be thoroughly coated externally with a suitable protective compound, in the field, just prior to installation. A good treatment would be one coat of red lead paint and two coats of black asphalt.
    - Tank should be fabricated of heavy gauge metal or fiberglass, and should bear the Underwriters' label.
    - Tank shall be installed in strict accordance with all governing fire building codes and environmental regulations.
    - Above ground tanks with properly designed and constructed containment may be used.
    - Fill end of tank should be four to six inches lower than other end.
    - Tank should be adequately anchored by means of a concrete pad and/or suitable hardware.

STEAM, HOT WATER AND COOLING PIPING

- Pipe tunnels are recommended, and should be large enough to work in. This recommendation applies to those cases where pipe must be placed below grade or below floor slab. (Please see next item).
- Heating or cooling pipe should never be placed underground or below slab on grade unless there is no other choice. Condensate lines, which must necessarily be placed underground at times, should be copper, Type "K", or some other material that is especially corrosion resistant. Fittings for copper pipe should be wrought type, and joints should be made with 95-5 solder or better.
- When it is necessary to install condensate pipe underground (that is, under a slab on grade), the practice of placing the pipe, wherever possible, outside the periphery of the building is highly preferable to placing it under the slab.
- Insulation in the boiler room should have a protective jacket applied. Factory provided jackets are not sufficient. Aluminum jackets are acceptable.

- Pipe anchoring and provisions for expansion (by means of expansion fittings, swing joints or expansion loops) must be provided where necessary.

- Install unions in all pipe lines for the removal of traps, valves, strainers, etc., except when the fitting is the combination union or flange type.

- A piping hookup detail for each piece of heating and cooling apparatus, including boilers, pumps, hot water generators and tanks, converters, radiation units, forced air heating and cooling units and drip assemblies, and for all points where special piping conditions exist, should be shown on the plans.

- Pitch directions for all heating and cooling (water) lines should be shown on the plans.

- The locations of piping runs (such as above ceilings, exposed at ceilings, etc.) should be indicated by notes on plan drawings.

- In a combination hot water-chilled water system incorporating a boiler, piping must be arranged and valved so that chilled water cannot circulate through the boiler (NCBRR). Also, hot water must not circulate through the chiller.

RADIATION AND UNIT HEATERS

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

- Strap-on limit controls, to prevent cold operation, should be installed on all unit heaters and cabinet heaters that are not used also for ventilation or cooling. Unit heaters in shops, for example, that are desired for circulating air separately from heating may include an additional on-off automatic control to accomplish this.

- Valves, balancing cocks and traps should be accessible (not behind covers without access panels.

- The fronts and ends of radiation covers should have a minimum thickness of 16 gauge.

CONTROLS

- Engineers should specify in detail all controls, describe in detail all controls, and describe sequences of operation.

- All controls, starters, switches, etc., should be permanently labeled after installation.

- Heating control diagrams should appear on the plans.
- Rigid guards, of cast iron or similar construction, are needed to cover thermostats in gymnasiums, dressing rooms, shops, corridors, restrooms and other unsupervised areas. All thermostats should be located on the plans.

- When an induced draft fan is used, a prepurge and low draft switch should be installed. Postpurge should not be used on stoker installations. Manufacturer's recommended pipe size from the breeching to the controller must be followed.

- Any control circuit for any kind of space heating device or water heater should be a phase to ground circuit. A phase to phase circuit should not be used. Voltages recommended are 120 volts, 277 volts and 24 volts.

- As an important factor in conserving fuels and energy it is of the utmost importance that (1) clock control and (2) night setback control be provided for all space heating and cooling equipment. Also, clocks or timing controls are applicable to exhaust fans.

- In most cases, cooling equipment should be turned off altogether during unoccupied periods (nights, weekends and holidays).

- The control consideration referred to here means turning off all equipment, including pumps, unless some of it is needed to prevent freezing.

- Boilers should be controlled in such a manner as to use the least possible amount of fuel during off heating periods.

HOT WATER HEATING SYSTEMS

- Feed or makeup water to the boiler should be fed at the return connection to the boiler and shall be piped to comply with the installation requirements of the NCBRR.

- There should be a valved bypass around the pressure regulating valve serving the system.

- The low water cutoff should be installed normally in the riser line off the boiler nozzle (NCBRR, part 2).

- A balancing line is good practice if more than one compression tank is used.

- Air control fittings at boilers and compression tanks are necessary. On large installations the use of separate chamber air elimination devices is recommended; these are pressure vessels and must be so treated. A shutoff valve shall be installed in the pipe line to each expansion tank for servicing.

- Hot water circulating (heating) pumps should have bronze impellers.

- Reverse return design of hot water heating or chilled water system piping is highly desirable, and should be used.

- Automatic valves should be the same size as the pipes except where modulating valves are used.
- In multiple boiler installations, piping arrangement at boilers and pumps should be such that water flow is equally divided through each boiler. In general, pumping away from the boiler(s) to the system is by far the most workable method.
- All compression tanks should be specified to meet ASME Code construction, and be so stamped. Sight glasses should not be installed on tanks.
- Manual type air vents should always be used instead of the automatic type.
- For economical reasons, the installation of standby pumps is not recommended. When warranted, a spare motor could be supplied. There may be times when parallel pumping could be a worthwhile consideration.
    - Pumps shall have a cutoff valve on each side for servicing. One valve may be an air tested balancing cock.
    - A simple flow diagram is usually a big help in defining the system.
    - Boilers must never be piped for reverse flow. Pump away from the boiler.

STEAM HEATING SYSTEMS

- The low water cutoff and safety water feeder should be set at a level two and one half inches below the normal water level of the boiler (NCBRR, Section 5, Rule 20).
- The condensate pump should be sized for the net capacity of the boiler.
- The condensate pump should have a cast iron receiver.
- Vertical, underground type pumps are preferred over floor-mounted types installed in pits.

GAS HEATING SYSTEMS, GAS BURNERS AND GAS-FIRED BOILERS

- Gas heating systems, direct-fired shall be installed in accordance with provisions of the NCSBC. Any other type of direct-fired system is not permissible.
- When a direct-fired, gas system is to be used for a public school building, it is urgently recommended and requested that the designing engineer and architect hold a meeting in the preliminary stages with School Planning and the Department of Insurance, if necessary, to discuss the matter in detail. This would be highly beneficial to all parties concerned with respect to system and

equipment selections, and in avoiding design considerations prohibited by code and/or law.

- Gas burners, for boiler firing, are recommended to be of the atmospheric (nonpressure type in the lower range of sizes (up to approximately 2,000,000 btu input). Factory engineered units, incorporating boiler and burner, are preferred over other types.

- Use and proper application of the best grades of gas combustion equipment and safety controls are mandatory. All equipment and controls should be specified to be in strict accordance with manufacturers' recommendations and the best accepted practices, and they must meet requirements of the AGA. The engineer is reminded here that control equipment set forth in printed material by manufacturers, although it is probably adequate from a safety standpoint, is usually minimum. Hence, combustion control components should be carefully engineered to produce the degree of safety and performance needed in public school applications. Attention is called to the requirements of NCBRR, Section .0600, Rule .606.

- The approved methods of installing gas piping, and the types of pipe and fittings to be used are of considerable importance. Specifications and/or plans should state these items in detail. The requirements of NFPA 54 are mandatory, and hence should be adequately shown and described.

- Gas piping test should be the same as that referred to in the Plumbing Systems, Gas Systems.

- In gas-fired boiler installations consider the installation of combination gas-oil burners to provide dual fuel capability.

- Pipe lines venting gas from appliances or devices shall terminate outside the building.

VENTILATING

- School Planning, recognizing the importance of proper ventilation, recommends that consideration be given to providing mechanical ventilation for all the occupied spaces in a public school building. Minimum quantities of air would then at least meet requirements of the NCSBC.

- Mechanical ventilation may be provided by means of a separate intake and exhaust system, or by means of integration with the heating-cooling system. The latter method is much preferred.

- When ventilation air is introduced into a space, adequate provision must be made for air relief.

- Variable volume ventilation systems, whether separate or integrated with heating or cooling equipment, are very useful in the North Carolina climate.

- Mechanical ventilation is vital to gymnasiums, locker rooms, certain storage rooms, dressing rooms, laundries, toilet rooms and janitor's closets. It is appropriate to provide for year-round, timed operation of ventilation equipment for areas where uniforms are stored. A sound trap should be installed in a duct system serving two or more toilet rooms.

- Food storage room ventilation: This is necessary, and should be done by means of introducing outside fresh air near the floor and expelling exhaust air through the roof, all by gravity flow.

- Paint spray rooms demand special treatment with respect to ventilation and safety requirements. Paint spray booths, commercial type, are recommended. If one is not to be used but a paint spray room is desired, the engineer should be careful to investigate this matter thoroughly with respect to regulations and codes. Paint spray areas are considered hazardous locations.

AIR CONDITIONING (COOLING)

- Cooling is recognized as a desirable and useful feature in public schools. Cooling should be considered for schools or portions of schools that will be used for either full or part-time summer school programs.

- Cooling should be provided for all interior classrooms without exception.

- Any of the types of cooling systems that conform to good engineering practices are acceptable. The type of system used, however, should be given careful consideration with respect to each individual case. The economics of both the first cost and the operating and maintenance cost should be analyzed.

- It is looked upon as good practice to consider provisions for future cooling in any new school that is not to have cooling installed initially. System design, related equipment and services could all be considered in the light of adding cooling at a later time.

- Cooling load summaries should be shown on the plans in the same manner as for heating.

- Consideration should be given to providing humidification control in air conditioning systems. This is very important in media centers and when conditioned spaces are carpeted.

- In central plant A/C systems careful selection of the refrigeration equipment is important. Proper evaluation should be made of capacities, flexibility, space requirements, noise and vibration factors, operating and maintenance costs, etc. Load diversity should be considered where applicable. The type of refrigeration machinery to be used, reciprocating, centrifugal, hermetic or open should be carefully investigated and evaluated.

- Self-contained, unitary A/C equipment is acceptable where applicable. However, such equipment should be very carefully evaluated with respect to life expectancy, capacity limitations, ventilating capability and noise factors.

- Window type A/C units are not recommended, and should be used only as a last resort.

ELECTRICAL AND LIGHTING SYSTEMS

GENERAL

- The electrical plans shall include a single line or riser diagram showing service conduit size, service wire size and type (or bus duct), panels, switches, overcurrent device sizes, transformers (when used in the secondary system), feeder conduit sizes, feeder wire sizes and complete grounding and bonding details. Specifications shall describe quality of materials and methods of installation.

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

- The North Carolina General Statues require that all electrical equipment, devices and apparatus sold and used in this state shall be evaluated for safety and listed by an accredited listing agency (NCGS 66-25). The specifications shall indicate that requirement.

- The 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 and total panel load.

- The emergency system shall be kept separate from all other wiring (NEC 700-17).

- Where wire and equipment is oversized for future expansion or for equipment which may be added in the future, some notation of this on the plans is helpful to everyone concerned.

- The entire system shall be color coded. Painting or taping should not be applied to wire of size number six or smaller.

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

- When long runs of wire are used, voltage drop should be considered (independent of spare capacity).

- The electrical plans shall bear the seal of the engineer who is responsible for the design and IS BY LAW REQUIRED to inspect and issue a Certificate of Compliance upon completion of the project (NCGS 133-1.1).

- All electrical plans and specifications should be coordinated for the heating and air conditioning controls, general lighting and plumbing wiring, and they shall comply with Chapter 32 of the NCSBC.

- Wiring and final connections for the control of mechanical equipment (heating and A/C controls) should be a part of the mechanical contract, but all work shall conform to the NEC and be accomplished by a licensed electrical contractor where required.

- The electrical plans shall show the secondary voltage at the single line or riser diagram, in panel and other schedules and in the lighting fixtures listing. Acceptable secondary voltage systems include:

    - 120/208 volts, four-wire, wye (for very small facilities).

    - 277/480 volts, three-phase, four-wire, wye (recommended for most new facilities).

- A single-phase system is acceptable only when the school is already single-phase and will remain very small after the addition, or when it is not possible to get a three-phase system.

- Delta systems (120/240 volts, three-phase, four-wire) are not recommended and should be used only where an addition to an existing facility operating at this voltage is constructed, and conversion to 120/208 volts wye is not economically feasible. Where no 240 volt, three-phase equipment is used, the voltage should be converted to 120/208 volts.

- Reference is made to step-down transformers within the secondary system. Details for transformer wiring, grounding and bonding should be shown on the drawings. Attention is called to the diagrams showing typical grounding and bonding that follow in this section. See NEC 450-3 for overcurrent protection requirements.

- Conductors supplied from the secondary terminals of a dry type transformer, within the secondary electrical system, must be provided with overcurrent protection in accordance with the requirements of the NEC 240-3 and 240-21. Conductors from a single-phase transformer can be an exception. See NEC 384-16(d) for service to a panelboard from the secondary of a transformer.

- Locations for step-down (dry type) transformers are important from the standpoints of safety and proper operation. Such transformers should never be located in wet areas or areas that are to be washed down by hosing. They should never be placed directly on the floor, but should be elevated to eliminate a possible water hazard. It is suggested that they be mounted on angle iron frames 18" high. Consideration should always be given to locating transformers in properly ventilated areas. Transformers should not be directly accessible to students, but rather should be placed in equipment rooms, closets or similar spaces not frequented by students. Please refer to the NEC 450-9, 10, 13 and 21.

- The specifications shall demand that all insulated conductors be marked on the outer covering, giving voltage, type and size so that they can be readily identified after installation. Conductors should be of copper wire.

- A complete electrical summary (example of a typical electrical summary follows this section) shall be shown on the plans, either all or in part as is appropriate for a given school, as follows:
    - The new load.
    - The existing load; where this information is not available, the owner should make arrangements to provide it either by the design consultant or some other means, such as demand reading from the electric utility.
    - The capacity provided for known future expansion.
    - The spare capacity provided if not for future expansion - state reasons; such as "Provision for Air Conditioning".
    - The total capacity of the service.
- In 20 ampere branch circuit wiring, some circuits are of such length that number ten wire must be used at the beginning of the run to avoid excessive voltage drop.
- For general classrooms, one 20 ampere circuit should be used for the receptacles only in one classroom, and nothing else should be on this circuit. This is a minimum requirement. Special classrooms will require different considerations.
- Reference is made to making buildings accessible to and usable by the physically handicapped (as required by the NCSBC and ADA). Please refer to Volume I-C for locations of telephones, lighting switches and other items.
- Electrical and mechanical engineers should work together closely to assure that all aspects of electrical energy usage in the building will be controlled to minimize costs to the owner. This means of course that reasonable methods of energy management, for any given project, should be properly applied. With regard to electrical and lighting system design, the electrical engineers' attention is called to NCSBC Chapter 32, Volume I, and the provisions therein that apply.
- Reference is made to gymnasiums, gymtoriums, play and other similar areas that have overhead mounted lighting fixtures. Methods of mounting overhead fixtures are important. Fixtures should be mounted as high as possible to be functional, should be mounted on swivels and should incorporate safety chains. Protective lens or wire cages should always be used, outside as well as inside, to protect the lamps. All of this should be done in an effort to prevent the falling of fixtures and/or debris (when hit or damaged) and thereby prevent injury to students below.

SERVICE ENTRANCE FEEDER

- The location of the nearest power pole should be shown on the plans. This would be in addition to locating the padmounted transformer when used.

- The service entrance feeder should be detailed and dimensioned, showing the point of attachment to the structure along with the clearance of service wires over finish grade, drives and roofs (NEC 230-24 through 230-29).

- Connections at the service head shall be made in accordance with requirements of the NEC, Article 230-54 (refer to Paragraphs (c), (f) and (g) in particular).

- Underground services are recommended, both primary and secondary, and should be used in all cases unless the cost is unreasonable. Routing for the underground service should be shown on a plot or site plan.

SERVICE EQUIPMENT

- All service equipment shall be bonded up to and including the first overcurrent device (NEC 250-71).

- Specifications shall cover bonding, and bonding diagrams should be shown on the plans.

- The bond wire used to carry the fault current of a parallel service, where two or more conduits are using the same jumper, shall be sized on the combined conductor capacity and not on the capacity of one set of conductors (NEC 250-79).

- The emergency system shall be bonded up to and including its overcurrent device (NEC 250-G).

- Switches, cabinets and cutout boxes of the surface type and metal raceways, boxes and fittings mounted on walls subject to dampness shall not be attached directly to the wall surface but shall have at least a quarter inch air space between enclosures and the walls or other supporting surfaces (NEC 373-2).

- Cabinets and cutout boxes in switchgear shall be increased in size to accommodate extra connections (NEC 373-7).

- Each individual building or structure shall have its own ground and its own disconnecting means as required by the NEC (NEC 230-70, 230-84 and 250-24).

- Provide lightning protection at, or as near as possible, the service entrance, or the main panelboard. Supplementary protection for electronic equipment and computers must be provided.

- The grounding electrode system connections shall be to the building water main (metallic pipe) and ground rods and shall be accessible. Building steel may be used where accessible. Point of attachment shall be indicated on the plans. Refer to NEC 205-H. The size(s) of the grounding electrode conductor(s) shall be shown on the plans.

- When ground wires are protected by the use of conduits, the conduits and wires must be bonded together at both ends of the conduits (NEC 250-92).

- It is possible that plastic or other nonconductive pipe for building water service might be installed. However, this is not recommended by School Planning. The electrical engineer is requested, when it is appropriate, to communicate with the plumbing design engineer to inform him that nonconductive pipe is useless as an electrical ground, and that metallic pipe is needed and recommended. In any event, proper grounding must be established in accordance with the requirements of the NEC, Articles 250-81 through 86.

- Service equipment shall be specified as service equipment, and shall have the UL label as such.

- For equipment interrupting capacity, reference is made to NEC 110-9. The fault current (or KVA) rating from the power company should be indicated on the plans on or near where the service entrance is indicated in the single line or riser diagram.

- Due to the derating effect of heat on electrical equipment and wiring, electrical service equipment should not be located in boiler rooms. If electrical equipment has to be located in a boiler room, it should be in a completely separate enclosure exclusively for that equipment and placed as far from the boiler as possible. Under no circumstances should electrical equipment be located in a room with a coal-fired or propane-fired boiler. In existing facilities where the boiler room is below grade, electrical renovations should relocate electrical equipment away from the boiler room.

DISTRIBUTION EQUIPMENT

- Place all electrical equipment, such as panelboards, disconnect switches, starters, restroom and corridor lighting switches in locations not normally accessible to students. Office areas, storage closets, attics, mechanical equipment rooms and "dry" custodial storage rooms are typical examples. Keyed switches for corridor and restroom lighting circuits are an acceptable alternate.

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

- Bolt-in type breakers should be used in panels.

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

- Do not allow more than one solid or stranded wire under one lug or screw type terminal unless it is approved for such use (NEC 110-14).

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

- Consider harmonic distortions from computers, copy machines, printers, lighting fixtures and other equipment and size the feeder and panelboard neutrals accordingly and specify transformers for use with nonlinear loads.

- Spare conduits should be included where spare breakers are provided in flush mounted panels.
- Where the number of overcurrent devices are such that it becomes necessary to provide two panelboards mounted side by side, sufficient information shall be furnished the contractor to permit conduits to be run to the proper enclosure.
- Proper panelboard protection is necessary (NEC 384).
- Provide lightning and surge protection where TV, computer and telecommunications equipment is located.
- The use of transformers to convert 208 volts to 240 volts for use in home economics ranges is not recommended. The electrical engineer should inform the architect and owner that 208 volt equipment should be used.

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 refrigeration rooms, dishwasher locations, and other such places that are likely to be subjected to water or moisture (NEC 410-4 and 370-5).
- Use GFI receptacles within six feet of all lavatories, sinks and other wet locations, and for whirlpools.
- Do not use flush floor-type receptacles in kitchens or like places subject to washing down and mopping.
- At least one duplex outlet is required in the boiler room and at least one shall be within 75 feet of any and all inside and outside mechanical and plumbing equipment, including roof mounted (1993 NEC will change distance to 25 feet).
- Junction and pull boxes, as a minimum, shall be sized according to Code (NEC 370-18).
- Provide disconnect switches for water heaters, where they are located out of sight of the panelboards feeding them.
- A multiwire branch circuit, as defined by the NEC, Section 210-4, shall be connected in such a manner that the neutral will not carry more than the maximum load of any one of the "hot conductors" in the circuit.
- All locknuts must be tightened during installation (NEC 300-10).
- Do not load branch circuits to more than 80 percent of their rated capacity (NEC 210-23).

- Fluorescent fixtures mounted on combustible, low density, cellulose fiberboard shall be installed as required by the Code (NEC 410-M).

- Maximum allowable load for lighting is 2.5 watts per gross square foot. See the NCSBC Section 3202.6 - Lighting. However, much less is required when using fluorescent, metal halide and high pressure sodium lighting fixtures.

MOTORS AND EQUIPMENT

- Where raceway flexibility is desired at the point of connection to the motor or piece of equipment, flexible conduit must be installed in accordance with Code requirements (NEC 350).

- Thermal overload protection shall be provided for every motor as required by Code (NEC 430, Par.C). Running overcurrent protection for three-phase motors must be provided in each phase, all as required in NEC, Article 430-37. Each motor shall be within sight of its disconnecting means. More than fifty feet is considered out of sight. (See the NEC, 430-H).

- Caution should be used in selecting 480 volt equipment for kitchens. Most kitchen equipment operates from 120 or 208 volts, single-phase or 208 volts, three-phase.

- Most new shop equipment operates at 120 or 208 volts, single-phase or 208 volts, three- phase.

EMERGENCY AND EXIT LIGHTING SYSTEMS AND POWER

- Emergency and exit lighting are required by the NCSBC. Attention is directed to Section 1118-Exit Illumination and Signs. All school buildings, regardless of age, shall have both exit and emergency lighting.

- Illuminated exit signs shall be strategically placed where they may be seen from anywhere in corridors (both directions), gymnasiums, 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. Fluorescent lamps should be used in exit lighting fixtures for the normal power source illumination and incandescents for emergency battery output only. Extended life incandescents should be used. The LED type exit lighting fixtures, which are UL listed, may be used in competitive bidding or when on State Contract.

- Due to the amount of failures experienced by owners, battery operated fluorescent lighting fixtures will not be accepted for emergency lighting systems. Halogen lamps should be used on battery operated emergency lighting.

- Three-way and four-way switches shall not be used in the emergency system (NEC 700-20).

- Manually operated switches for the exit and/or emergency system shall be accessible only to authorized personnel (NEC 700-20).

- The emergency system shall not be controlled from the stage of an assembly area (NEC 700-21).

- Cafeterias, gymnasiums, auditoriums and other assembly areas that will accommodate more than 100 persons shall have emergency illumination. Many school buildings have interior spaces, with no available daylight, that are occupied by students. Examples of such spaces might be classrooms, restrooms, corridors (where the condition is unavoidable), locker and dressing rooms. These spaces shall have emergency illumination provided to prevent total blackout in case of power failure. Unswitched night lights shall be provided in these same spaces.

- In areas where metal halide or high pressure sodium lighting are used (mercury vapor should not be used) a supplementary lighting system should be provided to illuminate an area during a momentary power outage. The metal halide lighting fixtures in particular take an extended period of time to return to full illumination. This supplementary system should be fluorescent lighting, but quartz type fixtures are available to use with the metal halide or high pressure sodium fixtures.

- Special provisions in the NCSBC require the application of particular types of emergency power sources. Refer to Table 1118 in Chapter 11 of this code.

- Battery powered exit and emergency illumination systems are usually preferred over generators. Ease of maintenance is one reason. Battery powered systems are recommended except on larger facilities, where emergency generators may be more cost effective, or if the owner prefers the emergency generator system.

FIRE ALARM, SMOKE AND HEAT DETECTION SYSTEMS

- Manual fire alarm systems are required for all new school buildings. New buildings added to existing campuses, additions to existing buildings and major renovations require a manual fire alarm system, regardless of whether the other existing facilities do or do not have a fire alarm system. Refer to NCSBC, Section 903.1.1.

- An automatic fire alarm system, properly designed and installed, may be used instead of a manual system. Refer to the NCSBC, Sections 903.1.2 and 903.2.5.

- Automatic smoke detectors are required in specific functions. Refer to NCSBC, Volume III, Sections 515. Other locations include both sides of smoke doors, storage rooms, electrical rooms, etc.

- Rate of rise heat detectors should be installed in boiler and furnace rooms.

- Alarm horns/strobe lights shall be located to satisfy the requirements of the ADA and the Fire Safety Codes. Outside alarms are recommended to alert persons to not enter and to alert neighbors of the alarm during unoccupied periods.

- All smoke and heat detectors including, but not limited to, those which activate the shutdown feature of air handling units, shall be tied into the fire alarm system and activate the alarms, both visual and audible.

GENERAL ILLUMINATION

- Close cooperation by the architect, engineer and school administrator(s) must be achieved to obtain the good lighting system design necessary for a proper visual environment. There are always at least four factors, directly related to the visual environment, that must be considered when designing the lighting system. These are:

  (a) Levels of illumination

  (b) Reflectances (and ranges of reflectances)

  (c) Brightness (and brightness ratios)

  (d) Contracts

- A table of recommended levels of illumination for schools can be found following herein. See ANSI/IES RP3-1988 (or latest addition) "Guide for Educational Facilities Lighting."

- The overall procedure for designing the lighting system might follow such a course as this:

1. Establish desired environment
   a. Brightness and brightness ratios
   b. Colors and textures
   c. Method of daylighting and daylight controls

2. Establish reference task and required illumination levels
   a. General or academic classrooms
   b. Special purpose areas - labs, libraries, shops, etc.

3. Establish general illumination system
   a. Distribution characteristics and energy usage of light sources
   b. Coordinate with effect of task visibility
   c. Coordinate with total environment
      (1) Characteristics of heat and noise production
      (2) Color acceptability
      (3) Special and esthetic characteristics

4. Establish supplementary illumination (task lighting)
   a. Chalkboards
   b. Special tasks
   c. Special areas

5. Establish audiovisual requirements

6. Analyze economics (life cycle cost analysis)
   a. Capital expense
   b. Maintenance expense
   c. Electrical energy cost

- In rooms larger than 200 square feet, double switching (or more if electrically necessary) is required. See the NCSBC, Section 3202.6-Lighting. In rooms where three lamp or four lamp fixtures are utilized, be certain that all inside lamps are switched separately from the outside lamps in a uniform manner.

- Use energy savings lamps and ballasts when replacing existing fixtures. Eventually federal law will require the manufacture of only energy savings lamps and ballasts. Electronic ballasts will eventually replace most uses for present ballasts. If regular lamps and ballasts are used when relamping or replacing ballasts, some present lighting circuits may become overloaded, so replacements should always be the energy savings types.

- Outdoor lighting for parking lots, walkways and security should be done with respect to the owner's desires, adequate lighting of areas in traveling to and from the building, and for the purpose of discouraging vandalism. High pressure sodium fixtures are normally used and are strongly recommended. Metal halide fixtures may be used if high pressure sodium fixtures are not wanted by the school district.

- Athletic field lighting and wiring require some careful thought. In addition to the consideration of lighting intensities, fixture selection, arrangement and fixture quality, the engineer should be concerned with the safety of the installations, and the requirements of both the NEC and the National Electrical Safety Code. Underground distribution of 277/480 volts is recommended and encouraged with metal halide lighting fixtures. High voltage distribution is not recommended because school systems do not have the equipment nor qualified people to maintain it.

- Because incandescent lamps use five times the energy and power required for fluorescent and metal halide lamps, they should not be used except in pipe chases, storage rooms and stage flood lighting. Mercury vapor lamps use almost twice the energy and power used by metal halides, so they should never be used (some manufacturers plan to discontinue manufacture of mercury vapor lamps and fixtures). Dimming equipment can be used on fluorescent and metal halide lighting fixtures. Self extinguishing metal halide (and mercury vapor) lamps shall be used to prevent ultraviolet radiation burns when the lamps are broken.

- The use of motion detectors, infrared or other electronic switching devices which are sensitive to the presence of people in a room are encouraged. These devices will turn off lighting fixtures when everyone leaves a room. A 10 minute delay is recommended to prevent damage to fluorescent or metal halide lamps and ballasts, which may occur when people go in or come out of a room frequently.

- As an energy conservation measure, interior lighting systems can be controlled by photoelectric switches, just as outdoor lighting systems have been for years. These switches may be used to reduce inside lighting levels when natural lighting permits and will allow full illumination on cloudy days and at night. However, frequent operations of fluorescent, metal halide and high pressure sodium fixtures will damage ballasts and lamps, so careful consideration must be given to the design of switching circuits. On partly cloudy days when the photoelectric switches are subjected to frequent changes in the levels of natural illumination, lighting circuits will be subjected to rapid on-off switching if proper design and installation is not performed.

SOUND SYSTEMS AND CLOCK AND BELL SYSTEMS

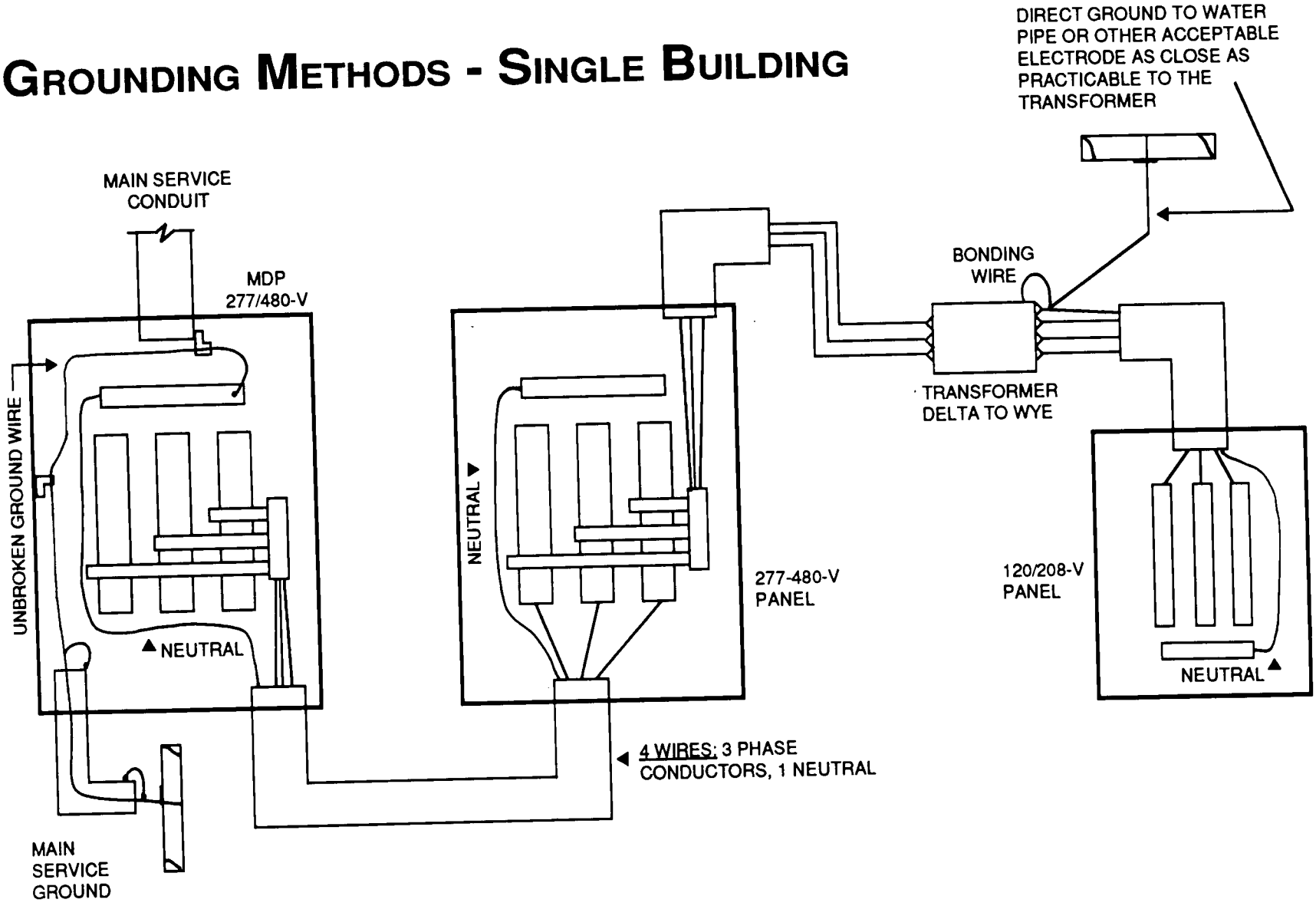
- Sound systems may be simple or somewhat complex as the owner desires. Systems should be designed for two-way communication, and for school wide sound distribution from one central point. In the initial design, it is recommended that the degree of sophistication be limited to a system that the owner will actually make use of.

- Clock and bell systems provide for the orderly control of periods within the school day, and are recommended. Systems and equipment should be kept reasonably simple in the best interest of both operation and maintenance.

- Complex clock systems that are continually out of order are obviously undesirable and expensive to purchase and maintain. Clocks which operate directly from 120 volt receptacles (or even batteries) are encouraged, unless an integrated system of television, intercom, class change bells and interior telephones is selected, which have time displayed on television sets.

SEE - "GUIDELINES TO PROVIDE UNIFORM WIRING SERVICE FOR TELECOMMUNICATION IN NORTH CAROLINA PUBLIC SCHOOLS", July, 1991, and "A PRIMER ON CABLING DESIGN AND IMPLEMENTATION: CONSIDERATIONS FOR DECISION MAKERS", May, 1992, published by the Division of Media and Technology, Department of Public Instruction. These publications, which were provided to every superintendent of public schools in North Carolina, include recommendations on the installations for Television Reception and Distribution Systems; Master Antenna Television (MATV), Closed Circuit Television (CCTV), Community Antenna Television (CATV), Multiple Source Television (MSTV); computer, telephone and data systems wiring. The use of these publications is suggested for all new construction, renovations and additions for all schools, new or existing, in North Carolina.

GROUNDING METHODS - SINGLE BUILDING

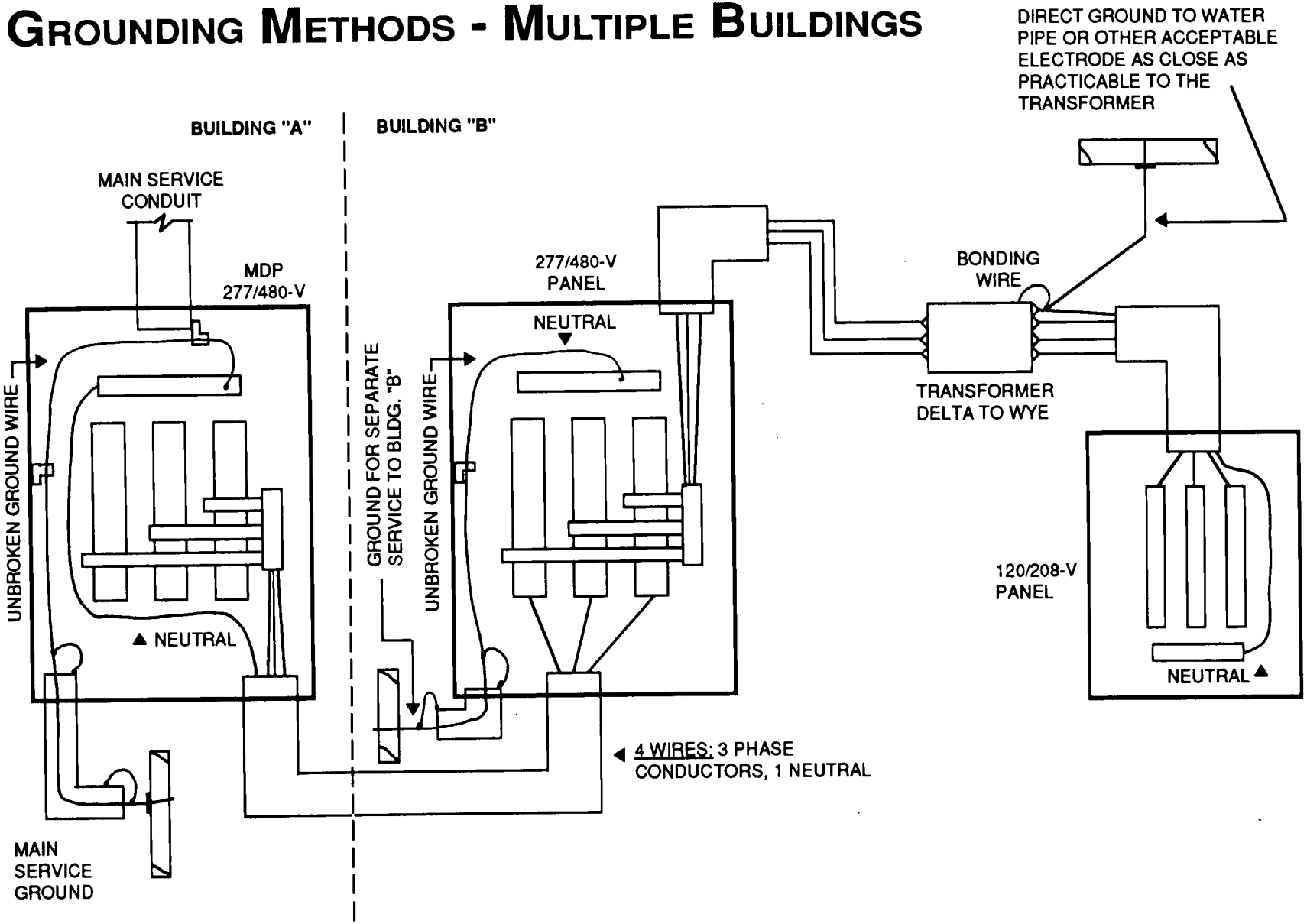


29

277/480-VOLT AND 120/208-VOLT SYSTEMS SHOWING GROUNDING METHOD
THIS DIAGRAM IS FOR ONE BUILDING ONLY ON THE SITE

NOTE: REFER TO THE N.E.C. 250-26

GROUNDING METHODS - MULTIPLE BUILDINGS



277/480-VOLT AND 120/208-VOLT SYSTEMS SHOWING GROUNDING METHOD
THIS DIAGRAM IS FOR MORE THAN ONE BUILDING ON THE SITE

NOTE: REFER TO THE N.E.C. 250-26

TYPICAL ELECTRICAL SUMMARY

ELECTRICAL LOAD SUMMARY

(A) SERVICE

277/480 VOLTS, 3-PHASE, 4-WIRE WYE WITH FULL NEUTRAL: 1600 AMPERE SWITCHBOARD AND 1200 AMPERE SERVICE ENTRANCE WITH EMPTY CONDUIT TO INCREASE SERVICE ENTRANCE TO 1600 AMPERES.

120/208 VOLTS, 3 PHASE, 4 WIRE WYE FOR RECEPTACLE AND SMALL POWER LOADS.

(B) CONNECTED LOAD	KW		AMPS	
(1) EXIST. BLDG.				
LTG.	228.8		275	
REC. & SPARES	138.0		166	
KITCHEN	329.0		395	
WATER HTR.	84.0		101	
SUB-TOTALS		779.8		937
(2) NEW BLDG.				
LTG.	104.0		125	
REC. & SPARES	86.0		103	
SUB-TOTALS		190		228
		969.8		1165
(3) FUT. AIR COND. & OTHER LOADS		433.6		520
TOTALS		1403.4		1685

RECOMMENDED LIGHTING SYSTEMS WITH ILLUMINATION LEVELS

INTERIOR LOCATIONS	MAINTAINED ILLUMINATION IN FOOT-CANDLES* MINIMUM	MAXIMUM	TYPE OF LIGHTING FIXTURES
AUDITORIUMS			
SEATING AREA	10	15	FLUORESCENT (DIMMING OR MULTIPLE SWITCHING)
STAGE SET-UP	20	30	FLUORESCENT (WARM WHITE)
CONCERTS ON STAGE	50	75	FLUORESCENT (WARM WHITE-STAGE ONLY)
DRAMA WITH ACCENTS	VAR.	100	INCANDESCENT (TRACKS WITH DIMMING EQUIPMENT)
CAFETERIAS			
KITCHEN/SERVING AREA	50	75	FLUORESCENT (WARM WHITE)
DINING ROOM	10	20	FLUORESCENT (WARM WHITE)
CASHIERS	20	30	FLUORESCENT (TASK LIGHTING)
DISH WASHING	20	30	FLUORESCENT (WET LOCATION APPROVED)
CLASSROOMS			
GENERAL	50	75	FLUORESCENT
ART	50	75	FLUORESCENT (WARM WHITE)
COMPUTER	50	75	FLUORESCENT (INDIRECT LIGHTING)
DRAFTING	75	100	FLUORESCENT
STUDY HALLS	50	75	FLUORESCENT
HOME ECONOMICS	50	75	FLUORESCENT
LABORATORIES			
GENERAL	50	75	FLUORESCENT
DEMONSTRATION	100	150	FLUORESCENT (TASK LIGHTING)
LIPREADING	100	150	FLUORESCENT
MUSIC	50	75	FLUORESCENT
SEWING	75	100	FLUORESCENT (TASK LIGHTING)
SHOPS	50	75	FLUORESCENT (HIGHER LEVELS CAN BE USED FOR DETAIL WORKS)
TYPING	50	75	FLUORESCENT
CORRIDORS AND STAIRWELLS (USE REMOTE OR KEYED SWITCHING)			
MIDDLE AND HIGH	20	30	FLUORESCENT
ELEMENTARY	10	15	FLUORESCENT
TROPHY CASES	50	75	COMPACT FLUORESCENT
WALL "WASHINGS"	MIN. AMOUNTS		COMPACT FLUORESCENT
GYMNASIUMS			
MULTIPLE SWITCHING TO OBTAIN VARIOUS LEVELS - COMPETITION GAMES VERSUS PHYSICAL EDUCATION)			
COMPETITION BETWEEN SCHOOLS	30	50	METAL HALIDE
PHYSICAL EDUCATION	20	30	METAL HALIDE
LOCKERS AND SHOWERS	20	30	FLUORESCENT (WET LOCATION APPROVED)
ELEMENTARY (MULTIPURPOSE)	20	30	METAL HALIDE OR FLUORESCENT
MECHANICAL EQUIPMENT & BOILER ROOMS	20	30	FLUORESCENT (INDUSTRIAL FIXTURES) OR INCANDESCENT IF ON WHILE "TEMPORARILY" OCCUPIED

RECOMMENDED LIGHTING SYSTEMS WITH ILLUMINATION LEVELS

CONTINUED

INTERIOR LOCATIONS	MAINTAINED ILLUMINATION IN FOOT-CANDLES*		TYPE OF LIGHTING FIXTURES
	MINIMUM	MAXIMUM	
MEDIA CENTERS			
READING ROOM, CHECK IN/OUT, CARD FILES	50	75	FLUORESCENT
BOOK STACKS, MAGAZINE RACKS	30	50	FLUORESCENT
OFFICE AREAS	50	75	FLUORESCENT
AV AND OTHER STORAGE	7.5	10	FLUORESCENT
AV REPAIR	75	100	FLUORESCENT (TASK LIGHTING)
OFFICES			
GENERAL OFFICE WORK	75	100	FLUORESCENT
CLOSE WORK	100	150	FLUORESCENT (TASK LIGHTING)
TEACHER WORK ROOM	30	50	FLUORESCENT
CONFERENCE ROOM	30	50	FLUORESCENT
STORAGE ROOMS, PIPE CHASES, ATTICS, CRAWL SPACES	7.5	10	FLUORESCENT (OR INCANDESCENT IF ON "TEMPORARY" WHILE OCCUPIED)
SWIMMING POOLS	7.5	10	METAL HALIDE OR FLUORESCENT (WET LOCATION APPROVED)
WASHROOMS/GANG TOILETS	20	30	FLUORESCENT (USE REMOTE OR KEYED SWITCHING)
WASHROOMS/FACULTY TOILETS	10	15	FLUORESCENT
EXTERIOR LOCATIONS (ALL FIXTURES ARE TO BE SUITABLE FOR WET LOCATIONS AND OUTDOOR USE)			
BUILDING EXTERIOR	1	1 1/2	HIGH PRESSURE SODIUM OR METAL HALIDE FOR SECURITY PURPOSES
PARKING LOTS AND WALKWAYS	1	1 1/2	HIGH PRESSURE SODIUM OR METAL HALIDE (COMPACT FLUORESCENTS CAN BE USED FOR WALKWAYS)
SPORTS COMPLEXES			
SOCCER/FOOTBALL STADIUM	30	50	METAL HALIDE
BADMINTON/VOLLEY BALL/ TENNIS COURTS	20	30	METAL HALIDE
BASEBALL/SOFTBALL			
OUTFIELD	15	30	METAL HALIDE
INFIELD	20	50	METAL HALIDE
SEPARATE RUNNING TRACKS (NOT A PART OF A FOOTBALL OR BASEBALL STADIUM)	10	15	METAL HALIDE

* BASED ON IES RECOMMENDATIONS

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