

**ELECTRICAL SPECIFICATIONS**

**ELECTRICAL CONDUCTORS**

- A. MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:
  - 1. ALCAN CONDUCTORS CORPORATION; ALCAN CABLE DIVISION.
  - 2. AMERICAN INSULATED WIRE CORP.; A LEVITON COMPANY.
  - 3. GENERAL CABLE CORP.; LEVEL AND FLUSH WITH FINISHED FLOOR SURFACE.
  - 4. SENATOR WIRE & CABLE COMPANY.
  - 5. SOUTHWIRE COMPANY.
- B. COPPER CONDUCTORS: COMPLY WITH NEMA WC 70.
  - 1. CONDUCTOR INSULATION: COMPLY WITH NEMA WC 70 FOR TYPES THN, THHN, THHN, XHHW, UF, USE, AND SO.
  - 2. MULTICONDUCTOR CABLE: COMPLY WITH NEMA WC 70 FOR ARMORED CABLE, TYPE AC, METAL-CLAD CABLE, TYPE MC, TYPE SO, AND TYPE USE WITH GROUND WIRE.
- C. CONDUCTOR MATERIAL APPLICATIONS:
  - 1. COPPER: SOLD FOR NO. 10 AWG AND SMALLER; STRANDED FOR NO. 8 AWG AND LARGER.
- D. CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS:
  - 1. SERVICE ENTRANCES: TYPE THHN-THHN, SINGLE CONDUCTORS IN RACEWAY, TYPE SE OR USE MULTICONDUCTOR CABLE.
  - 2. EXPOSED FEEDERS: TYPE THHN-THHN, SINGLE CONDUCTORS IN RACEWAY.
  - 3. FEEDERS CONCEALED IN CEILING, WALLS, PARTITIONS, AND CRAWLSPACES: TYPE THHN-THHN, SINGLE CONDUCTORS IN RACEWAY.
  - 4. FEEDERS CONCEALED IN CONCRETE, BELOW SLABS-ON-GRADE, AND UNDERGROUND: TYPE THHN-THHN, SINGLE CONDUCTORS IN RACEWAY.
  - 5. FEEDERS INSTALLED BELOW RAISED FLOORING: TYPE THHN-THHN, SINGLE CONDUCTORS IN RACEWAY.
  - 6. EXPOSED BRANCH CIRCUITS, INCLUDING IN CRAWLSPACES: TYPE THHN-THHN, SINGLE CONDUCTORS IN RACEWAY, METAL-CLAD CABLE, TYPE MC.
  - 7. BRANCH CIRCUITS CONCEALED IN CEILING, WALLS, AND PARTITIONS: TYPE THHN-THHN, SINGLE CONDUCTORS IN RACEWAY, ARMORED CABLE, TYPE AC, METAL-CLAD CABLE, TYPE MC.
  - 8. BRANCH CIRCUITS CONCEALED IN CONCRETE, BELOW SLABS-ON-GRADE, AND UNDERGROUND: TYPE THHN-THHN, SINGLE CONDUCTORS IN RACEWAY.
  - 9. BRANCH CIRCUITS CONCEALED IN CEILING, WALLS, PARTITIONS, AND CRAWLSPACES: TYPE THHN-THHN, SINGLE CONDUCTORS IN RACEWAY, METAL-CLAD CABLE, TYPE MC.
  - 10. BRANCH CIRCUITS INSTALLED IN PATIENT CARE AREAS: TYPE HFC-MACP OR AC-HFC WITH ASSEMBLY CERTIFICATION AN EQUIPMENT GROUNDING CONDUCTOR AND A GREEN INSULATED EQUIPMENT GROUNDING CONDUCTOR CONNECTED TO ALL RECEPTABLES, METALLIC BOXES CONTAINING RECEPTABLES, AND ALL METALLIC EQUIPMENT CASINGS.

**GROUNDING**

- A. INSULATED CONDUCTORS: COPPER WIRE OR CABLE INSULATED FOR 600 V UNLESS OTHERWISE REQUIRED BY APPLICABLE CODE OR AUTHORITIES HAVING JURISDICTION.
  - 1. BARE COPPER CONDUCTORS:
    - a. STRANDED CONDUCTORS: ASTM B 3.
    - b. SOLID CONDUCTORS: ASTM B 8.
  - 2. BONDING CABLE: 28 KCMIL, 14 STRANDS OF NO. 17 AWG CONDUCTOR, 1/4 INCH (6 MM) IN DIAMETER.
  - 3. BONDING CONDUCTOR: NO. 4 OR NO. 6 AWG, STRANDED CONDUCTOR.
  - 4. BONDING JUMPER: COPPER TAPE, BRAIDED CONDUCTORS TERMINATED WITH COPPER FERRULES; 1-5/8 INCHES (41 MM) WIDE AND 1/16 INCH (1.6 MM) THICK.
- B. GROUNDING BUS: PREDRILLED RECTANGULAR BARS OF ANNEALED COPPER, 1/4 BY 4 INCHES (6.3 BY 100 MM) IN CROSS SECTION, WITH 9/32-INCH (7.14-MM) HOLES SPACED 1-1/8 INCHES (28 MM) APART. STAND-OFF INSULATORS FOR MOUNTING SHALL COMPLY WITH UL 891 FOR USE IN SWITCHBOARDS, 600 V. LEVEX, UNLESS TESTED AT 5000 V.
- C. CONNECTORS LISTED AND LABELED BY AN NRTL ACCEPTABLE TO AUTHORITIES HAVING JURISDICTION FOR APPLICATIONS IN WHICH USED AND FOR SPECIFIC TYPES, SIZES, AND COMBINATIONS OF CONDUCTORS AND OTHER ITEMS CONNECTED.
- D. BOLTED CONNECTORS FOR CONDUCTORS AND PIPES: COPPER OR COPPER ALLOY, PRESSURE TYPE WITH AT LEAST TWO BOLTS. PIPE CONNECTORS: CLAMP TYPE, SIZED FOR PIPE.
- E. WELDED CONNECTORS: EXOTHERMIC-WELDING KITS OF TYPES RECOMMENDED BY KIT MANUFACTURER FOR MATERIALS BEING JOINED AND INSTALLATION CONDITIONS.
- F. BUS-BAR CONNECTORS: MECHANICAL TYPE, CAST SILICON BRONZE, SOLDERLESS COMPRESSION-TYPE WIRE TERMINALS, AND LONG-BARREL, TWO-BOLT CONNECTION TO GROUND BUS BAR.
- G. CONDUCTORS: INSTALL SOLID CONDUCTOR FOR NO. 8 AWG AND SMALLER, AND STRANDED CONDUCTORS FOR NO. 6 AWG AND LARGER UNLESS OTHERWISE INDICATED.
- H. ISOLATED GROUNDING CONDUCTORS: GREEN-COLORED INSULATION WITH CONTINUOUS YELLOW STRIPE. ON FEEDERS WITH ISOLATED GROUND, IDENTIFY GROUNDING CONDUCTOR WHERE VISIBLE TO NORMAL INSPECTION, WITH ALTERNATING BANDS OF GREEN AND YELLOW TAPE, WITH AT LEAST THREE BANDS OF GREEN AND TWO BANDS OF YELLOW.
- I. CONDUCTOR TERMINATIONS AND CONNECTIONS:
  - 1. PIPE AND EQUIPMENT GROUNDING TERMINATIONS: BOLTED CONNECTORS, UNDERGROUND CONNECTIONS. WELDED CONNECTORS EXCEPT AT TEST WELLS AND AS OTHERWISE INDICATED. CONNECTIONS TO GROUND RODS AT TEST WELLS: BOLTED CONNECTORS. CONNECTIONS TO STRUCTURAL STEEL: WELDED CONNECTORS.
- J. EQUIPMENT GROUNDING:
  - 1. INSTALL INSULATED EQUIPMENT GROUNDING CONDUCTORS TO COMPLY WITH THE NEC AND AS INDICATED ON THE DRAWINGS.

**ELECTRICAL HANGERS AND SUPPORTS**

- A. COMPLY WITH NECA 1 AND NECA 101 FOR APPLICATION OF HANGERS AND SUPPORTS FOR ELECTRICAL EQUIPMENT AND SYSTEMS EXCEPT IF REQUIREMENTS IN THIS SECTION ARE STRICTER. MAXIMUM SUPPORT SPACING AND MINIMUM HANGER ROD SIZE FOR RACEWAYS:
  - 1. SPACE SUPPORTS FOR EMT, IMC, AND RMC AS SCHEDULED IN NECA 1, WHERE ITS TABLE 1 LISTS MAXIMUM SPACINGS LESS THAN LISTED IN NFPA 70. MINIMUM ROD SIZE SHALL BE 1/4 INCH (6 MM) IN DIAMETER. MULTIPLE RACEWAYS OR CABLES: INSTALL TRAPEZOID-TYPE SUPPORTS FABRICATED WITH STEEL SLOTTED OR OTHER SUPPORT SYSTEM, SIZED SO CAPACITY CAN BE INCREASED BY AT LEAST 25 PERCENT IN FUTURE WITHOUT EXCEEDING SPECIFIED DESIGN LOAD LIMITS. SECURE RACEWAYS AND CABLES TO THESE SUPPORTS WITH TWO-BOLT CONDUIT CLAMPS, SPRING-STEEL CLAMPS DESIGNED FOR SUPPORTING SINGLE CONDUITS WITHOUT BOLTS MAY BE USED FOR 1-1/2-INCH (38-MM) AND SMALLER RACEWAYS SERVING BRANCH CIRCUITS AND COMMUNICATION SYSTEMS ABOVE SUSPENDED CEILING AND FOR FASTENING RACEWAYS TO TRAPEZOID SUPPORTS.
- B. SUPPORT INSTALLATION: COMPLY WITH NECA 1 AND NECA 101 FOR INSTALLATION REQUIREMENTS EXCEPT AS SPECIFIED IN THIS ARTICLE.
- C. RACEWAY SUPPORT METHODS: IN ADDITION TO METHODS DESCRIBED IN NECA 1, EMT, IMC, AND RMC MAY BE SUPPORTED BY OPENINGS THROUGH STRUCTURE MEMBERS, AS PERMITTED IN NFPA 70.
- D. STRENGTH OF SUPPORT ASSEMBLIES: WHERE NOT INDICATED, SELECT SIZES OF COMPONENTS SO STRENGTH WILL BE ADEQUATE TO CARRY PRESENT AND FUTURE STATIC LOADS WITHIN SPECIFIED LOADING LIMITS. MINIMUM STATIC DESIGN LOAD USED FOR STRENGTH DETERMINATION SHALL BE HEIGHT OF SUPPORTED COMPONENTS PLUS 200 LB (90 KG).
- E. MOUNTING AND ANCHORAGE OF SURFACE-MOUNTED EQUIPMENT AND COMPONENTS: ANCHOR AND FASTEN ELECTRICAL ITEMS AND THEIR SUPPORTS TO BUILDING STRUCTURAL ELEMENTS BY THE FOLLOWING METHODS UNLESS OTHERWISE INDICATED BY CODE:
  - 1. TO WOOD: FASTEN WITH LAG SCREWS OR THROUGH BOLTS.
  - 2. TO NEW CONCRETE: BOLT TO CONCRETE INSERTS.
  - 3. TO MASONRY: APPROVED TOGGLE-TYPE BOLTS ON HOLLOW MASONRY UNITS AND EXPANSION ANCHOR FASTENERS ON SOLID MASONRY UNITS.
  - 4. TO EXISTING CONCRETE: EXPANSION ANCHOR FASTENERS.
  - 5. INSTEAD OF EXPANSION ANCHORS, POWDER-ACTUATED DRIVEN THREADED STUDS PROVIDED WITH LOCK WASHERS AND NUTS MAY BE USED IN EXISTING STANDARD-WEIGHT CONCRETE 4 INCHES (100 MM) THICK OR GREATER. DO NOT USE FOR ANCHORAGE TO LIGHTWEIGHT-AGGREGATE CONCRETE OR FOR SLABS LESS THAN 4 INCHES (100 MM) THICK.
  - 6. TO STEEL: WELDED THREADED STUDS COMPLYING WITH AWS D1.1/D11M, WITH LOCK WASHERS AND NUTS OR BEAM CLAMPS (MSS TYPE 19, 21, 23, 25, OR 27) COMPLYING WITH MSS SP-69.
  - 7. TO LIGHT STEEL: SHEET METAL SCREWS.
  - 8. DRILL HOLES FOR EXPANSION ANCHORS IN CONCRETE AT LOCATIONS AND TO DEPTHS THAT AVOID REINFORCING BARS.

**ELECTRICAL CONDUIT**

- A. METAL CONDUIT AND TUBING
  - 1. MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:
    - a. AFC CABLE SYSTEMS, INC.
    - b. ALLIED TUBE & CONDUIT; A TYCOO INTERNATIONAL LTD. CO.
    - c. ANAMET ELECTRICAL, INC.; ANACONDA METAL HOSE.
    - d. ELECTRI-FLEX CONDUIT COMPANY; NEMA FB 1.
    - e. MAVERICK TUBE CORPORATION.
    - f. O-2 GEENEY; A UNIT OF GENERAL SIGNAL.
    - g. WHEATLAND TUBE COMPANY.
  - 2. RIGID STEEL CONDUIT: ANSI C80.1.
  - 3. ALUMINUM RIGID CONDUIT: ANSI C80.5.
  - 4. IMC: ANSI C80.6.
  - 5. PVC-COATED STEEL CONDUIT: PVC-COATED RIGID STEEL CONDUIT.
  - 6. COMPLY WITH NEMA RN 1.
  - 7. COATING THICKNESS: 0.040 INCH (1 MM), MINIMUM.
  - 8. EMT: ANSI C80.3.
  - 9. FMC: ZINC-COATED STEEL.
  - 10. LFMC: FLEXIBLE STEEL CONDUIT WITH PVC JACKET.
  - 11. FITTINGS FOR CONDUIT (INCLUDING ALL TYPES AND FLEXIBLE AND LIQUIDTIGHT), EMT, AND CABLE: NEMA FB 1; LISTED FOR TYPE AND SIZE RACEWAY WITH WHICH USED, AND FOR APPLICATION AND ENVIRONMENT IN WHICH INSTALLED.
    - a. FITTINGS FOR EMT: STEEL SET-SCREW OR COMPRESSION TYPE, DIE-CAST IS NOT ACCEPTABLE.
    - b. COATING FOR FITTINGS FOR PVC-COATED CONDUIT: MINIMUM THICKNESS, 0.040 INCH (1 MM), WITH OVERLAPPING SLEEVES PROTECTING JOINED JOINTS.
    - c. JOINT COMPOUND FOR RIGID STEEL CONDUIT OR IMC: LISTED FOR USE IN CABLE CONNECTOR ASSEMBLIES, AND COMPOUNDED FOR USE TO LUBRICATE AND PROTECT THREADED RACEWAY JOINTS FROM CORROSION AND ENHANCE THEIR CONDUCTIVITY.
    - d. SURFACE METAL RACEWAYS: GALVANIZED STEEL WITH SNAP-ON COVERS. MANUFACTURER'S STANDARD ENAMEL FINISH IN COLOR SELECTED BY ARCHITECT.
- B. MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:
  - 1. THOMAS & BETTS CORPORATION.
  - 2. WALKER SYSTEMS, INC.; WREMOLD COMPANY (THE).
  - 3. WREMOLD COMPANY (THE); ELECTRICAL SALES DIVISION.
- C. BOXES, ENCLOSURES, AND CABINETS:
  - 1. MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:
    - a. COOPER CROUSE-HINDS; DIV. OF COOPER INDUSTRIES, INC.
    - b. EGS/APPLETON ELECTRIC.
    - c. HOFFMAN.
    - d. HUBBELL INCORPORATED; KILLARK ELECTRIC MANUFACTURING CO. DIVISION.
    - e. O-2/GEENEY; A UNIT OF GENERAL SIGNAL.
    - f. RAYCO; A HUBBELL COMPANY.
    - g. ROBROY INDUSTRIES, INC.; ENCLOSURE DIVISION.
    - h. THOMAS & BETTS CORPORATION.
    - i. WALKER SYSTEMS, INC.; WREMOLD COMPANY (THE).
  - 2. SHEET METAL OUTLET AND DEVICE BOXES: NEMA OS 1.
  - 3. CAST-METAL OUTLET AND DEVICE BOXES: NEMA OS 1, FERROUS ALLOY, TYPE FD, WITH GASKETED COVER.
  - 4. METAL FLOOR PLATES: CAST METAL, FULLY ADJUSTABLE, RECTANGULAR.
  - 5. SMALL SHEET METAL PULL AND JUNCTION BOXES: NEMA OS 1.
  - 6. CAST-METAL ACCESS, PULL, AND JUNCTION BOXES: NEMA FB 1, GALVANIZED, CAST IRON WITH GASKETED COVER.
  - 7. HINGED-COVER ENCLOSURES: NEMA 250, TYPE 1, WITH CONTINUOUS-HINGE COVER WITH FLUSH LATCH, UNLESS OTHERWISE INDICATED.
    - a. METAL ENCLOSURES: STEEL, FINISHED INSIDE AND OUT WITH MANUFACTURER'S STANDARD ENAMEL.
      - i. IN STANDARD PARTITIONS, WHERE 1/2" AND 3/4" CONDUITS ARE EMPLOYED: 4" SQUARE BY 2-1/8" DEEP BOXES WITH 1-GANG OR 2-GANG PLASTER COVERS SHALL BE USED, NO. 450-SPL.
      - ii. IN THIN PARTITIONS MEASURING 3-1/2" OR LESS: 4" SQUARE BY 1-1/2" DEEP BOXES WITH 1-GANG OR 2-GANG PLASTER COVERS SHALL BE USED, NO. 45-SPL.
      - iii. IN STANDARD PARTITIONS, WHERE CONDUITS OF A SIZE GREATER THAN 3/4" ARE EMPLOYED: 4" SQUARE BY 2-1/8" DEEP BOXES WITH 1-GANG OR 2-GANG PLASTER COVERS SHALL BE USED, NO. 450-B SERIES. THE OUTLET BOXES SHALL BE LOCATED WHEREBY NO TWO (2) OUTLET BOXES ARE INSTALLED CLOSER THAN 24" ON CENTER, AND SECURELY ATTACHED TO THE PARTITION STUDS, WITH AT LEAST ONE (1) PARTITION STUD SEPARATING THE OUTLET BOXES. IT IS NOT ACCEPTABLE TO SECURE OUTLET BOXES ONLY TO DRYWALL PARTITION.
    - b. CABINETS:
      - i. NEMA 250, TYPE 1, GALVANIZED-STEEL BOX WITH REMOVABLE INTERIOR PANEL AND REMOVABLE FRONT, FINISHED INSIDE AND OUT WITH MANUFACTURER'S STANDARD ENAMEL.
      - ii. HINGED DOOR IN FRONT COVER WITH FLUSH LATCH AND CONCEALED HINGE.
      - iii. KEY LATCH TO LOCK PANELBOARDS.
      - iv. METAL BARRIERS TO SEPARATE WIRING OF DIFFERENT SYSTEMS AND VOLTAGE.
      - v. ACCESSORY FEET WHERE REQUIRED FOR FREESTANDING EQUIPMENT.
  - 8. OUTDOORS: APPLY RACEWAY PRODUCTS AS SPECIFIED BELOW, UNLESS OTHERWISE INDICATED:
    - a. EXPOSED CONDUIT: RIGID STEEL CONDUIT.
    - b. CONCEALED CONDUIT, ABOVEGROUND: RIGID STEEL CONDUIT, EMT, RMC.
    - c. UNDERGROUND CONDUIT: RMC, TYPE EPC-40-PVC, DIRECT BURIED.
    - d. CONNECTION TO VIBRATING EQUIPMENT (INCLUDING TRANSFORMERS AND HYDRAULIC, PNEUMATIC, ELECTRIC SOLENOID, OR MOTOR-DRIVEN EQUIPMENT): LFMC.
    - e. BOXES AND ENCLOSURES, ABOVEGROUND: NEMA 250, TYPE 3E.
  - 9. WITH THE FOLLOWING INDOOR APPLICATIONS, UNLESS OTHERWISE INDICATED:
    - a. EXPOSED, NOT SUBJECT TO PHYSICAL DAMAGE: EMT.
    - b. EXPOSED, SUBJECT TO SEVERE PHYSICAL DAMAGE: EMT.
    - c. EXPOSED AND SUBJECT TO SEVERE PHYSICAL DAMAGE: RIGID STEEL CONDUIT, INCLUDES RACEWAYS IN THE FOLLOWING LOCATIONS: LOADING DOCK, CORRIDORS USED FOR TRAFFIC OF MECHANIZED CARTS, FORKLIFFS, AND PALLET-HANDLING UNITS, MECHANICAL ROOMS.
    - d. CONCEALED IN CEILING AND INTERIOR WALLS AND PARTITIONS: EMT.
    - e. CONNECTION TO VIBRATING EQUIPMENT (INCLUDING TRANSFORMERS AND HYDRAULIC, PNEUMATIC, ELECTRIC SOLENOID, OR MOTOR-DRIVEN EQUIPMENT): FMC, EXCEPT USE LFMC IN DAMP OR WET LOCATIONS.
    - f. DAMP OR WET LOCATIONS: RIGID STEEL CONDUIT.
    - g. RACEWAYS FOR OPTICAL FIBER OR COMMUNICATIONS CABLE IN SPACES USED FOR ENVIRONMENTAL AIR: PLENUM-TYPE, OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY, EMT.
    - h. RACEWAYS FOR OPTICAL FIBER OR COMMUNICATIONS CABLE RISERS IN VERTICAL SHAFTS: RISER-TYPE, OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY, EMT.
    - i. RACEWAYS FOR CONCEALED GENERAL PURPOSE DISTRIBUTION OF OPTICAL FIBER OR COMMUNICATIONS CABLE: GENERAL-USE, OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY, RISER-TYPE, OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY, PLENUM-TYPE, OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY, EMT.
    - j. BOXES AND ENCLOSURES: NEMA 250, TYPE 1, EXCEPT USE NEMA 250, TYPE 4X, STAINLESS STEEL, IN DAMP OR WET LOCATIONS.
    - k. MINIMUM RACEWAY SIZE: 1/2-INCH (16-MM) TRADE SIZE.
    - l. RACEWAY FITTINGS: COMPATIBLE WITH RACEWAYS AND SUITABLE FOR USE AND LOCATION.
      - i. RIGID AND INTERMEDIATE STEEL CONDUIT: USE THREADED RIGID STEEL CONDUIT FITTINGS, UNLESS OTHERWISE INDICATED.
      - ii. PVC EXTERNALLY COATED, RIGID STEEL CONDUITS: USE ONLY FITTINGS LISTED FOR USE WITH THAT MATERIAL. PATCH AND SEAL ALL JOINTS, NUTS, AND SCREWS IN PVC COATING AFTER INSTALLING CONDUITS AND FITTINGS. USE SEALANT RECOMMENDED BY FITTING MANUFACTURER.
  - 10. INSTALLATION WITH NECA 1 FOR INSTALLATION REQUIREMENTS APPLICABLE TO PRODUCTS SPECIFIED EXCEPT WHERE REQUIREMENTS ON DRAWINGS OR IN THIS ARTICLE ARE STRICTER.
- D. KEEP RACEWAYS AT LEAST 6 INCHES (150 MM) AWAY FROM PARALLEL RUNS OF FLUES AND STEAM OR HOT-WATER PIPES. INSTALL HORIZONTAL RACEWAY RUNS ABOVE WATER AND STEAM PIPING.
- E. COMPLETE RACEWAY INSTALLATION BEFORE STARTING CONDUCTOR INSTALLATION.
- F. SUPPORT RACEWAYS AS SPECIFIED IN "HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS." AD. ARRANGE SUB-UPS SO CURVED PORTIONS OF BENDS ARE NOT VISIBLE ABOVE THE FINISHED SLAB.
- G. INSTALL NO MORE THAN THE EQUIVALENT OF THREE 90-DEGREE BENDS IN ANY CONDUIT RUN EXCEPT FOR COMMUNICATIONS CONDUITS, FOR WHICH FEWER BENDS ARE ALLOWED.
- H. CONCEAL CONDUIT AND EMT WITH FINISHED WALLS, CEILING, AND FLOORS, UNLESS OTHERWISE INDICATED.
- I. RACEWAYS EMBEDDED IN SLABS:
  - 1. RUN CONDUIT LARGER THAN 1-INCH (27-MM) TRADE SIZE, PARALLEL OR AT RIGHT ANGLES TO MAIN REINFORCEMENT. WHERE AT RIGHT ANGLES TO REINFORCEMENT, PLACE CONDUIT CLOSE TO SLAB SUPPORT.
  - 2. ARRANGE RACEWAYS TO CROSS BUILDING EXPANSION JOINTS AT RIGHT ANGLES WITH EXPANSION FITTINGS.
  - 3. CHANGE FROM EMT TO RMC, TYPE EPC-40-PVC, RIGID STEEL CONDUIT, OR IMC BEFORE RISING ABOVE THE FLOOR.
- J. THREADED CONDUIT JOINTS, EXPOSED TO WET, DAMP, CORROSIVE, OR OUTDOOR CONDITIONS: APPLY LISTED COMPOUND TO THREADS OF RACEWAY AND FITTINGS BEFORE MAKING UP JOINTS. FOLLOW COMPOUND MANUFACTURER'S WRITTEN INSTRUCTIONS.
- K. RACEWAY TERMINATIONS AT LOCATIONS SUBJECT TO MOISTURE OR VIBRATION: USE INSULATING BUSHINGS TO PROTECT CONDUCTORS, INCLUDING CONDUCTORS SMALLER THAN NO. 4 AWG.
- L. INSTALL PULL WIRES IN EMPTY RACEWAYS. USE POLYPROPYLENE OR MONOFILAMENT PLASTIC LINE WITH NOT LESS THAN 200-LB (90-KG) TENSILE STRENGTH. LEAVE AT LEAST 12 INCHES (300 MM) OF SLACK AT EACH END OF PULL WIRE.
- M. RACEWAYS FOR OPTICAL FIBER AND COMMUNICATIONS CABLE: INSTALL RACEWAYS, METALLIC AND NONMETALLIC, RIGID AND FLEXIBLE, AS FOLLOWS:
  - 1. 3/4-INCH (19-MM) TRADE SIZE AND SMALLER: INSTALL RACEWAYS IN MAXIMUM LENGTHS OF 50 FEET (15 M).
  - 2. 1-INCH (25-MM) TRADE SIZE AND LARGER: INSTALL RACEWAYS IN MAXIMUM LENGTHS OF 75 FEET (23 M).
  - 3. INSTALL WITH A MAXIMUM OF TWO 90-DEGREE BENDS OR EQUIVALENT FOR EACH LENGTH OF RACEWAY UNLESS DRAWINGS SHOW STRICTER REQUIREMENTS. SEPARATE LENGTHS WITH PULL OR JUNCTION BOXES OR TERMINATIONS AT DISTRIBUTION FRAMES OR CABINETS WHERE NECESSARY TO COMPLY WITH THESE REQUIREMENTS.
- N. INSTALL RACEWAY SEALING FITTINGS AT SUITABLE, APPROVED, AND ACCESSIBLE LOCATIONS AND FILL THEM WITH LISTED SEALING COMPOUND. FOR CONCEALED RACEWAYS, INSTALL EACH FITTING IN A FLUSH STEEL BOX WITH A BLANK COVER PLATE HAVING A FINISH SIMILAR TO THAT OF ADJACENT PLATES OR SURFACES. INSTALL RACEWAY SEALING FITTINGS AT THE FOLLOWING POINTS:
  - 1. WHERE CONDUITS PASS FROM WARM TO COLD LOCATIONS, SUCH AS BOUNDARIES OF REFRIGERATED SPACES.
  - 2. WHERE OTHERWISE REQUIRED BY NFPA 70.

- AP. FLEXIBLE CONDUIT CONNECTIONS: USE MAXIMUM OF 48 INCHES (1219 MM) OF FLEXIBLE CONDUIT FOR RECESSED AND SEMIRECESSED LIGHTING FIXTURES, EQUIPMENT SUBJECT TO VIBRATION, NOISE TRANSMISSION, OR MOVEMENT; AND FOR TRANSFORMERS AND MOTORS. USE LFMC IN DAMP OR WET LOCATIONS.
- AQ. RECESSED BOXES IN MASONRY WALLS: SAW-OUT OPENING FOR BOX IN CENTER OF CELL OF MASONRY BLOCK, AND INSTALL BOX FLUSH WITH SURFACE OF WALL.
- AR. SET METAL FLOOR BOXES LEVEL AND FLUSH WITH FINISHED FLOOR SURFACE.
- AS. FIRESTOPPING:
  - 1. APPLY FIRESTOPPING TO ELECTRICAL PENETRATIONS OF FIRE-RATED FLOOR AND WALL ASSEMBLIES TO RESTORE ORIGINAL FIRE-RESISTANCE RATING OF ASSEMBLY. PROVIDE SLEEVES FOR FLOOR PENETRATIONS EXTENDING 2" ABOVE FLOOR EXCEPT IN FINISHED AREAS WHERE COORDINATED WITH ARCHITECT.

**PANELBOARDS**

- A. ENCLOSURES: FLUSH- AND SURFACE-MOUNTED CABINETS. RATED FOR ENVIRONMENTAL CONDITIONS AT INSTALLED LOCATION, INDOOR DRY AND CLEAN LOCATIONS: NEMA 250, TYPE 1. OUTDOOR LOCATIONS: NEMA 250, TYPE 3R. WET OR DAMP INDOOR LOCATIONS: NEMA 250, TYPE 4X STAINLESS STEEL.
- B. FRONT: SECURED TO BOX WITH CONCEALED TRIM BOLTS. FOR SURFACE-MOUNTED FRONTS, MATCH BOX DIMENSIONS; FOR FLUSH-MOUNTED FRONTS, OVERLAP BOX.
- C. HINGED FRONT COVER: ENTIRE FRONT TRIM HINGED TO BOX AND WITH STANDARD DOOR WITH HINGED TRIM COVER.
- D. FINISHES:
  - 1. PANELS AND TRIM: GALVANIZED STEEL, FACTORY FINISHED IMMEDIATELY AFTER CLEANING AND PRETREATING WITH MANUFACTURER'S STANDARD TWO-COAT, BAKED-ON FINISH CONSISTING OF PRIME COAT AND THERMOSETTING TOPOCOAT.
- E. BACK BOXES: GALVANIZED STEEL.
- F. FUNGUS PROOFING: PERMANENT FUNGICIDAL TREATMENT FOR OVERCURRENT PROTECTIVE DEVICES AND OTHER COMPONENTS.
- G. DIRECTORY CARD: INSIDE PANELBOARD DOOR, MOUNTED IN TRANSPARENT CARD HOLDER.
- H. INCOMING MAINS LOCATION: TOP AND BOTTOM.
- I. PHASE, NEUTRAL AND GROUND BUSES:
  - 1. MATERIAL: TIN-PLATED ALUMINUM OR HARD-DRAWN COPPER, 98 PERCENT CONDUCTIVITY. EQUIPMENT GROUND BUS: ADEQUATE FOR FEEDER AND BRANCH-CIRCUIT EQUIPMENT GROUNDING CONDUCTORS; BONDED TO BOX.
- J. CONDUCTOR CONNECTORS: SUITABLE FOR USE WITH CONDUCTOR MATERIAL AND SIZES. MATERIAL: TIN-PLATED ALUMINUM OR HARD-DRAWN COPPER, 98 PERCENT CONDUCTIVITY. MAIN AND NEUTRAL LUGS: COMPRESSION TYPE. GROUND LUGS AND BUS-CONFIGURED TERMINATORS: COMPRESSION TYPE, FEED-THROUGH LUGS. COMPRESSION TYPE, SUITABLE FOR USE WITH CONDUCTOR MATERIAL. LOCATE AT OPPOSITE END OF BUS FROM INCOMING LUGS OR MAIN DEVICE. RATED FOR CONNECTION OF 75 DEG C INSULATED CONDUCTORS.
- K. PANELBOARD SHORT-CIRCUIT CURRENT RATING: FULLY RATED TO INTERRUPT SYMMETRICAL SHORT-CIRCUIT CURRENT AVAILABLE AT TERMINALS.
- L. LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS:
  - 1. MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:
    - a. GENERAL ELECTRIC INC.; CUTLER-HAMMER BUSINESS UNIT.
    - b. GENERAL ELECTRIC COMPANY; GE CONSUMER & INDUSTRIAL.
    - c. SIEMENS ENERGY & AUTOMATION, INC.
  - 2. PANELBOARDS: NEMA PB 1, LIGHTING AND APPLIANCE BRANCH-CIRCUIT TYPE. MAINS: CIRCUIT BREAKER OR LUGS ONLY. MATERIAL: TIN-PLATED ALUMINUM OR HARD-DRAWN COPPER, 98 PERCENT CONDUCTIVITY. WITHOUT DISTURBING ADJACENT UNITS.
  - 3. DOORS: CONCEALED HINGES; SECURED WITH FLUSH LATCH WITH TUMBLER LOCK; KEYS ALIKE.

**LIGHTING FIXTURES**

- A. GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS.
  - 1. RECESSED FIXTURES: COMPLY WITH UL 1598. WHERE LER IS SPECIFIED, TEST ACCORDING TO NEMA LE 5A.
  - 2. INCANDESCENT FIXTURES: COMPLY WITH UL 1598. WHERE LER IS SPECIFIED, TEST ACCORDING TO NEMA LE 5 AND NEMA LE 5A AS APPLICABLE.
  - 3. FLOURESCENT FIXTURES: COMPLY WITH UL 1598. WHERE LER IS SPECIFIED, TEST ACCORDING TO NEMA LE 5 AND NEMA LE 5A AS APPLICABLE.
  - 4. LED FIXTURES:
    - a. LISTED AND LABELED AS DEFINED IN NFPA 70, BY A QUALIFIED TESTING AGENCY, AND MARKED FOR INTENDED LOCATION AND APPLICATION.
    - b. EACH LUMINAIRE TYPE SHALL BE BINNED WITH A THREE-STEP MACADAM ELIPSE TO ENSURE COLOR CONSISTENCY AMONG LUMINAIRES.
    - c. METAL PARTS: FREE OF BURRS AND SHARP CORNERS AND EDGES. SHEET METAL COMPONENTS: STEEL UNLESS OTHERWISE INDICATED. FORM AND SUPPORT TO PREVENT WARPING AND SAGGING. DOORS, FRAMES, AND OTHER INTERNAL ACCESS: SMOOTH OPERATING, FREE OF LIGHT LEAKAGE UNDER OPERATING CONDITIONS AND DESIGNED TO PERMIT RELAMPING WITHOUT USE OF TOOLS. DESIGNED TO PREVENT DOORS, FRAMES, LENSES, DIFFUSERS, AND OTHER COMPONENTS FROM FALLING ACCIDENTALLY DURING RELAMPING AND WHEN SECURED IN OPERATING POSITION.
- B. DIFFUSERS AND CLOSES:
  - 1. ACRYLIC LIGHTING DIFFUSERS: 100 PERCENT VIRION ACRYLIC PLASTIC. HIGH RESISTANCE TO YELLOWING AND OTHER CHANGES DUE TO AGE, EXPOSURE TO HEAT, AND UV RADIATION.
  - 2. LENS THICKNESS: AT LEAST 0.125 INCH (3.175 MM) MINIMUM UNLESS OTHERWISE INDICATED.
  - 3. UV STABILIZED.
  - 4. GLASS: ANNEALED CRYSTAL GLASS UNLESS OTHERWISE INDICATED.
- C. FACTORY-APPLIED LABELS: COMPLY WITH UL 1598. INCLUDE RECOMMENDED LAMPS AND BALLASTS. LABELS SHALL BE LOCATED WHERE THEY WILL BE READILY VISIBLE TO SERVICE PERSONNEL, BUT NOT SEEN FROM NORMAL VIEWING ANGLES WHEN LAMPS ARE IN PLACE. LABEL SHALL INCLUDE THE FOLLOWING LAMP AND BALLAST CHARACTERISTICS:
  - 1. USE ONLY AND INCLUDE SPECIFIC LAMP TYPE.
  - 2. LAMP DIAMETER CODE (T-4, T-5, T-8, T-12, ETC.), TUBE CONFIGURATION (TWIN, QUAD, TRIPLE, ETC.), BASE TYPE, AND NOMINAL WATTAGE FOR FLOURESCENT AND COMPACT FLOURESCENT LUMINAIRES.
  - 3. LAMP TYPE, WATTAGE, BULB TYPE (ED17, B056, ETC.) AND COATING (CLEAR OR COATED) FOR HID LUMINAIRES.
  - 4. START TYPE (PREHEAT, RAPID START, INSTANT START, ETC.) FOR FLOURESCENT AND COMPACT FLOURESCENT LUMINAIRES.
  - 5. ANSI BALLAST TYPE (M98, M57, ETC.) FOR HID LUMINAIRES.
  - 6. OCT AND OR FOR ALL LUMINAIRES.
- D. ELECTROMAGNETIC INTERFERENCE FILTERS: FACTORY INSTALLED TO SUPPRESS CONDUCTED ELECTROMAGNETIC INTERFERENCE AS REQUIRED BY MIL-STD-461E. FABRICATE LIGHTING FIXTURES WITH ONE FILTER ON EACH BALLAST INSTALLED TO REQUIRE A FILTER.

**BALLASTS**

- A. BALLASTS FOR LINEAR FLOURESCENT LAMPS, GENERAL REQUIREMENTS FOR ELECTRONIC BALLASTS:
  - 1. COMPLY WITH UL 935 AND WITH ANSI C82.11.
  - 2. DESIGNED FOR TYPE AND QUANTITY OF LAMPS SERVED.
  - 3. BALLASTS SHALL BE DESIGNED FOR FULL LIGHT OUTPUT UNLESS ANOTHER BF, DIMMER, OR BI-LEVEL CONTROL IS INDICATED.
  - 4. SOUND RATING: CLASS A.
  - 5. TOTAL HARMONIC DISTORTION RATING: LESS THAN 10 PERCENT.
  - 6. TRANSIENT VOLTAGE PROTECTION: IEEE C82.41.1 AND IEEE C82.41.2, CATEGORY A OR BETTER.
  - 7. OPERATING FREQUENCY: 42 KHZ OR HIGHER.
  - 8. LAMP CURRENT CREST FACTOR: 1.7 OR LESS.
  - 9. BF: 0.88 OR HIGHER.
  - 10. POWER FACTOR: 0.95 OR HIGHER.
  - 11. PANEL LEVEL CIRCUITS: MULTIPLE LAMP BALLASTS SHALL COMPLY WITH ANSI C82.11 AND SHALL BE CONNECTED TO MAINTAIN FULL LIGHT OUTPUT ON SURVIVING LAMPS IF ONE OR MORE LAMPS FAIL.
- B. LUMINAIRES CONTROLLED BY OCCUPANCY SENSORS SHALL HAVE PROGRAMMED-START BALLASTS.
- C. ELECTRONIC PROGRAMMED-START BALLASTS FOR T8 AND T5 AND T5HO LAMPS: COMPLY WITH ANSI C82.11 AND THE FOLLOWING:
  - 1. LAMP END-OF-LIFE DETECTION AND SHUTDOWN CIRCUIT FOR T5 DIAMETER LAMPS.
  - 2. AUTOMATIC LAMP STARTING AFTER LAMP REPLACEMENT.
  - 3. ELECTROMAGNETIC BALLASTS: COMPLY WITH ANSI C82.1; ENERGY SAVING, HIGH-POWER FACTOR, CLASS P, AND HAVING AUTOMATIC-RESET THERMAL PROTECTION.
  - 4. ELECTRONIC BALLASTS: COMPLY WITH ANSI C82.11 AND THE FOLLOWING:
    - a. FACTORY FINISHED IMMEDIATELY AFTER CLEANING AND PRETREATING WITH MANUFACTURER'S STANDARD TWO-COAT, BAKED-ON FINISH CONSISTING OF PRIME COAT AND THERMOSETTING TOPOCOAT.
  - 5. SINGLE BALLASTS FOR MULTIPLE LIGHTING FIXTURES: FACTORY WREED WITH BALLAST ARRANGEMENTS AND BUNDLED EXTENSION WIRING TO SUIT FINAL INSTALLATION CONDITIONS WITH MINOR MODIFICATION OR REWIRING IN THE FIELD.
- D. BALLASTS FOR COMPACT FLOURESCENT LAMPS:
  - 1. DESCRIPTION: ELECTRONIC-PROGRAMMED RAPID-START TYPE, COMPLYING WITH UL 935 AND WITH ANSI C 82.11, DESIGNED FOR TYPE AND QUANTITY OF LAMPS INDICATED. BALLAST SHALL BE DESIGNED FOR FULL LIGHT OUTPUT UNLESS DIMMER OR BI-LEVEL CONTROL IS INDICATED:
    - a. LAMP END-OF-LIFE DETECTION AND SHUTDOWN CIRCUIT.
    - b. AUTOMATIC LAMP STARTING AFTER LAMP REPLACEMENT.
    - c. SOUND RATING: CLASS A.
    - d. TOTAL HARMONIC DISTORTION RATING: LESS THAN 20 PERCENT.
    - e. TRANSIENT VOLTAGE PROTECTION: IEEE C82.41.1 AND IEEE C82.41.2, CATEGORY A OR BETTER.
    - f. OPERATING FREQUENCY: 20 KHZ OR HIGHER.
    - g. LAMP CURRENT CREST FACTOR: 1.7 OR LESS.
    - h. BF: 0.95 OR HIGHER UNLESS OTHERWISE INDICATED.
    - i. POWER FACTOR: 0.95 OR HIGHER.
    - j. INTERFERENCE: COMPLY WITH 47 CFR 18, CH. 1, SUBPART C, FOR LIMITATIONS ON ELECTROMAGNETIC AND RADIO-FREQUENCY INTERFERENCE FOR NONCONSUMER EQUIPMENT.

**LED LAMPS**

- A. MINIMUM LUMENS PER SCHEDULED FIXTURE.
- B. MINIMUM ALLOWABLE EFFICACY OF 85 LM/W.
- C. CRI OF MINIMUM 80. CCT PER SCHEDULED FIXTURE.
- D. RATED LAMP LIFE OF 50,000 HOURS TO L50.
- E. DIMMABLE FROM 100 PERCENT TO 1 PERCENT OF MAXIMUM LIGHT OUTPUT.
- F. INTERNAL DRIVER.
- G. USER-REPLACEABLE LAMPS:
  - 1. BULB SHAPE COMPLYING WITH ANSI C78.79.
  - 2. LAMP BASE COMPLYING WITH ANSI C81.61 OR IEC 60061-1.

**WIRING DEVICES**

- A. MANUFACTURERS:
  - 1. COOPER WIRING DEVICES.
  - 2. HUBBELL INCORPORATED; WIRING DEVICE-KELLUMS.
  - 3. LEVITON MFG. COMPANY INC.
  - 4. PASS & SEYMOUR/LEGRAND; WIRING DEVICES & ACCESSORIES.
- B. ALL WIRING DEVICES TO BE WHITE OR COLOR AS SELECTED BY ARCHITECT.
- C. STRAIGHT BLADE RECEPTABLES:
  - 1. CONVENIENCE RECEPTABLES, 125 V, 20 A: COMPLY WITH NEMA WD 1, NEMA WD 6 CONFIGURATION 5-20R, AND UL 498. PRODUCTS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE ONE OF THE FOLLOWING:
    - a. LEVITON; 16341-W (SINGLE), 1632-W (DUPLICATE).
    - b. ANY EQUAL BY ABOVE LISTED MANUFACTURERS.
  - 2. ANY EQUAL BY ABOVE LISTED MANUFACTURERS.
- D. ISOLATED-GROUND, DUPLEX CONVENIENCE RECEPTABLES, 125 V, 20 A: COMPLY WITH NEMA WD 1, NEMA WD 6 CONFIGURATION 5-20R, AND UL 498. PRODUCTS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE ONE OF THE FOLLOWING:
  - 1. LEVITON; 16341-W (SINGLE), 1632-W (DUPLICATE).
  - 2. ANY EQUAL BY ABOVE LISTED MANUFACTURERS.
- E. GFCO RECEPTABLES:
  - 1. GENERAL DESCRIPTION: STRAIGHT BLADE, FEED-THROUGH TYPE, COMPLY WITH NEMA WD 1, NEMA WD 6, AND UL 943, CLASS A, AND INCLUDE INDICATOR LIGHT THAT IS LIGHTED WHEN DEVICE IS TRIPPED. DUPLEX GFCO CONVENIENCE RECEPTABLES, 125 V, 20 A: PRODUCTS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE ONE OF THE FOLLOWING:
    - a. LEVITON; 7899-W.
    - b. ANY EQUAL BY ABOVE LISTED MANUFACTURERS.
- F. SNAP SWITCHES, COMPLY WITH NEMA WD 1 AND UL 20. SWITCHES, 120/277 V, 20 A: PRODUCTS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE ONE OF THE FOLLOWING:
  - 1. LEVITON; 5621-2W (SINGLE POLE), 5622-2 (TWO POLE), 5623-2 (THREE WAY).
  - 2. ANY EQUAL BY ABOVE LISTED MANUFACTURERS.
- G. WALL-BOX DIMMERS, DIMMER SWITCHES: MODULAR, FULL-WAVE, SOLID-STATE UNITS WITH INTEGRAL ON-OFF SWITCHES, WITH ADJUSTABLE FREQUENCY AND DIMMER SUPPRESSION FILTERS. CONTROL: CONTINUOUSLY ADJUSTABLE SLIDER; WITH SINGLE-POLE OR THREE-WAY SWITCHING. COMPLY WITH UL 1472.
  - 1. INCANDESCENT LAMP DIMMERS: 120 V. CONTROL SHALL FOLLOW SQUARE-LAW DIMMING CURVE. ON-OFF SWITCH POSITIONS SHALL BYPASS DIMMER MODULE. 2000 W. DIMMERS SHALL REQUIRE NO DERATING WHEN GANGED WITH OTHER DEVICES.
  - 2. FLOURESCENT LAMP DIMMERS: MODULAR, COMPATIBLE WITH DIMMER BALLASTS; TRIM POTENTIOMETER TO ADJUST LOW-END DIMMING; DIMMER-BALLAST COMBINATION CAPABLE OF CONSISTENT DIMMING WITH LOW END NOT GREATER THAN 20 PERCENT OF FULL BRIGHTNESS.
  - 3. ACCEPTABLE MANUFACTURERS: LUTRON, LEVITON.
- H. VACUANCY/OCCUPANCY SENSORS, WALL-SWITCH SENSORS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE ONE OF THE FOLLOWING:
  - 1. LUTRON; MS-B102 (PROGRAMMED FOR VACANCY OR OCCUPANCY OPERATION AS SHOWN)
  - 2. ANY EQUAL BY NOVITAS, WATSTOPPER, LEVITON OR SENSOR SWITCH.
- I. DESCRIPTION: DUAL TECHNOLOGY TYPE, 120/2