

ELECTRICAL SPECIFICATIONS

ELECTRICAL CONDUCTORS

- A. MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:
 - ALCAN CONDUCTORS CORPORATION: ALCAN CABLE DIVISION.
 - AMERICAN INSULATED WIRE CORP.: A LEVITON COMPANY.
 - GENERAL CABLE CORPORATION.
 - SENATOR WIRE & CABLE COMPANY.
 - ZACHRY COMPANY.
- B. COPPER CONDUCTORS: COMPLY WITH NEMA NO. 70.
- C. EXPOSED INSULATION: COMPLY WITH NEMA NO. 70 FOR TYPES THIN, THIN-THIN, THINX, ULF, USE, AND SO.
- D. MULTICONDUCTOR CABLE: COMPLY WITH NEMA NO. 70 FOR ARMORED CABLE, TYPE AC, METAL-CLAD CABLE, TYPE MC, TYPE SC, AND TYPE WITH GROUND WIRE.
- E. CONDUCTOR MATERIAL APPLICATIONS:
 - CONDUCTOR: SOLID FOR NO. 10 AWG AND SMALLER; STRANDED FOR NO. 8 AWG AND LARGER.
- F. CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS:
 - 1. SERVICED ENTRANCES: TYPE THIN-THIN, SINGLE CONDUCTORS IN RACEWAY, TYPE SE OR USE MULTICONDUCTOR CABLE.
 - 2. FEEDERS: TYPE THIN-THIN, SINGLE CONDUCTORS IN RACEWAY.
 - 3. FEEDERS CONCEALED IN CEILING, WALLS, PARTITIONS, AND GRAMSPACES: TYPE THIN-THIN, SINGLE CONDUCTORS IN RACEWAY.
 - 4. FEEDERS CONCEALED IN CONCRETE, BELOW SLABS-ON-GRADE, AND UNDERGROUND: TYPE THIN-THIN, SINGLE CONDUCTORS IN RACEWAY.
 - 5. FEEDERS CONCEALED IN CONCRETE, BELOW SLABS-ON-GRADE, AND UNDERGROUND: TYPE THIN-THIN, SINGLE CONDUCTORS IN RACEWAY.
 - 6. EXPOSED BRANCH CIRCUITS, INCLUDING IN GRAMSPACES: TYPE THIN-THIN, SINGLE CONDUCTORS IN RACEWAY, METAL-CLAD CABLE, TYPE MC.
 - 7. BRANCH CIRCUITS CONCEALED IN CEILING, WALLS, AND PARTITIONS: TYPE THIN-THIN, 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 THIN-THIN, SINGLE CONDUCTORS IN RACEWAY.
 - 9. BRANCH CIRCUITS CONCEALED IN CONCRETE, BELOW SLABS-ON-GRADE, AND UNDERGROUND: TYPE THIN-THIN, SINGLE CONDUCTORS IN RACEWAY.
 - 10. BRANCH CIRCUITS INSTALLED BELOW RAISED FLOORING: TYPE THIN-THIN, SINGLE CONDUCTORS IN RACEWAY OR ARMORED CABLE, TYPE AC, METAL-CLAD CABLE, TYPE MC.
 - 11. BRANCH CIRCUITS INSTALLED IN PATIENT CARE AREAS: TYPE HOT-MAP OR AC-10F WITH ASSEMBLY CERTIFIED AS AN EQUIPMENT GROUNDING CONDUCTOR AND GREEN INSULATED EQUIPMENT GROUNDING CONDUCTOR CONNECTED TO ALL RECEPTACLE 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.
- B. BARE COPPER CONDUCTORS:
 - 1. SOLID CONDUCTORS: ASTM B 3.
 - 2. STRANDED CONDUCTORS: ASTM B 8.
 - 3. BONDING CABLE: 28 KCMIL, 14 STRANDS OF NO. 17 AWG CONDUCTOR, 1/4 INCH (6 MM) DIAMETER.
 - 4. BONDING WIRE: NO. 4 OR NO. 6 AWG, STRANDED CONDUCTOR.
 - 5. BONDING WIRE: COPPER TAP, BRADED CONDUCTORS TERMINATED WITH COPPER FERRULES, 1-5/8 INCHES (41 MM) WIDE AND 1/16 INCH (1.6 MM) THICK.
- C. GROUNDING BUS: PREDRILLED RECTANGULAR BARS OF ANNEALED COPPER, 1/4 BY 4 INCHES (6.3 BY 100 MM) IN CROSS SECTION, WITH 3/32-INCH (0.714-MM) HOLES SPACED 1-1/8 INCHES (29 MM) APART. STAND-OFF INSULATORS FOR MOUNTING SHALL COMPLY WITH UL 891 FOR USE IN SWITCHBOARDS, 600 V. LEXAN, IMPULSE TESTED AT 5000 V.
- D. 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.
- E. BOLTED CONNECTORS FOR CONDUCTORS AND PIPES: COPPER OR COPPER ALLOY, PRESSURE TIGHT WITH AT LEAST TWO BOLTS.
- F. WELDED CONNECTORS: EXOTHERMIC-WELDING KITS OF TYPES RECOMMENDED BY KIT MANUFACTURER FOR MATERIALS BEING JOINED AND INSTALLATION CONDITIONS.
- G. BUS-BAR CONNECTORS: MECHANICAL TYPE, CAST SILICON BRONZE, SOLDERLESS COMPRESSION-TYPE WIRE TERMINALS, AND LOW-BARREL, TWO-BOLT CONNECTION TO GROUND BUS BAR.
- H. CONDUCTORS: INSTALL SOLID CONDUCTOR FOR NO. 8 AWG AND SMALLER, AND STRANDED CONDUCTORS FOR NO. 6 AWG AND LARGER UNLESS OTHERWISE INDICATED.
- I. ISOLATED GROUNDING CONDUCTORS: GREEN-COLORED INSULATION WITH CONTINUOUS YELLOW STRIPE. ON FEEDERS WITH ISOLATED GROUND, IDENTIFY GROUNDING CONDUCTOR WHICH IS VISIBLE TO NORMAL INSPECTION, WITH ALTERNATING BANDS OF GREEN AND YELLOW TAPE, WITH AT LEAST THREE BANDS OF GREEN AND TWO BANDS OF YELLOW.
- J. CONDUCTOR TERMINATIONS AND CONNECTIONS: PIPE AND EQUIPMENT GROUNDING CONDUCTOR TERMINATIONS: BOLTED CONNECTORS, UNDERGROUND CONNECTIONS: WELDED CONNECTORS EXCEPT AT TEST WELLS AND AS OTHERWISE INDICATED. CONNECTIONS TO GROUND ROOF AT TEST WELLS: BOLTED CONNECTORS, CONNECTIONS TO STRUCTURAL STEEL: WELDED CONNECTORS.
- K. EQUIPMENT GROUNDING: 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 AS REQUIREMENTS IN THIS SECTION ARE STRICTER. MAXIMUM SUPPORT SPACING AND MINIMUM HANGER ROD SIZE FOR RACEWAY: SPACE SUPPORTS FOR EMT, IMC, AND IMC AS SCHEDULED IN NECA 1, WHERE ITS TABLE 1 LISTS MAXIMUM SPACINGS LESS THAN STATED IN NECA 70. MINIMUM ROD SIZE SHALL BE 1/4 INCH (6 MM) IN DIAMETER. MULTIPLE RACEWAYS OR CABLES: INSTALL TRAPEZE-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 COMMUNICATIONS SYSTEMS ABOVE SUSPENDED CEILING AND FOR FASTENING RACEWAYS TO TRAPEZE 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 IMC MAY BE SUPPORTED BY OPENINGS THROUGH STRUCTURE MEMBERS, AS PERMITTED IN NECA 70.
- D. STRENGTH OF SUPPORT ASSEMBLIES: WHERE NOT INDICATED, SELECT TYPES 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, POWER-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/D1.1M, WITH LOCK WASHERS AND NUTS OR BEAM CLAMPS (MS5 TYPE 19, 21, 23, 25, OR 27) COMPLYING WITH MSS SP-89.
 - 7. TO LIGHT STEEL: WELDED METAL BARS.
 - 8. DRILL HOLES FOR EXPANSION ANCHORS IN CONCRETE AT LOCATIONS AND TO DEPTHS THAT AVOID REINFORCING STEEL.

ELECTRICAL CONDUIT

- A. METAL CONDUIT AND TUBING MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:
 - 1. AFC CABLE SYSTEMS, INC.
 - 2. ALTEC INC.
 - 3. ALLED TUBE & CONDUIT; A TYCO INTERNATIONAL LTD. CO.
 - 4. ANAVET ELECTRICAL, INC.; ANACONDA METAL HOSE.
 - 5. ELECTRI-FLEX CO.
 - 6. MAVERICK TUBE CORPORATION.
 - 7. O-Z/GEENEY; A UNIT OF GENERAL SIGNAL.
 - 8. WHEATLAND TUBE COMPANY.
 - 9. STEEL CONDUIT AND COBI.
 - 10. ALUMINUM RIDG CONDUIT: ANSI C80.5.
 - 11. IMC: ANSI C80.6.
 - 12. PVC-COATED STEEL CONDUIT: PVC-COATED RIDG STEEL CONDUIT.
 - 13. COMPLY WITH NEMA RN 1.
 - 14. COATING THICKNESS: 0.040 INCH (1 MM), MINIMUM.
 - 15. EMT: ANSI C80.1.
 - 16. FMC: ZINC-COATED STEEL.
 - 17. FLEXIBLE STEEL CONDUIT WITH PVC JACKET.
 - 18. FITTINGS FOR EMT (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.
 - 19. FITTINGS FOR EMT: STEEL, SET-SCREW OR COMPRESSION TYPE, DE-CAST IS NOT ACCEPTABLE.
 - 20. COATING FOR FITTINGS FOR PVC-COATED CONDUIT: MINIMUM THICKNESS, 0.040 INCH (1 MM), WITH OVERLAPPING SLEEVES PROTECTING THREADED JOINTS.
 - 21. JOINT COMPOUND FOR RIDG 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.
 - 22. 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.; WIREMOLD COMPANY (THE).
 - 3. WIREMOLD COMPANY (THE); ELECTRICAL SALES DIVISION.
- C. BOXES, ENCLOSURES, AND CABINETS MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:
 - 1. CHRYSLER-HOUIDS; DIV. OF COOPER INDUSTRIES, INC.
 - 2. EGS/APPLETON ELECTRIC.
 - 3. HOFFMAN.
 - 4. HUBBELL INCORPORATED; KELLUM ELECTRIC MANUFACTURING CO. DIVISION.
 - 5. O-Z/GEENEY; A UNIT OF GENERAL SIGNAL.
 - 6. RACCO; A HUBBELL COMPANY.
 - 7. ROBROY INDUSTRIES, INC.; ENCLOSURE DIVISION.
 - 8. THOMAS & BETTS CORPORATION.
 - 9. WALKER SYSTEMS, INC.; WIREMOLD COMPANY (THE).
- D. SHEET METAL OUTLET AND DEVICE BOXES: NEMA OS 1.
- E. CAST-METAL OUTLET AND DEVICE BOXES: NEMA FB 1, FERROUS ALLOY, TYPE FD, WITH GASKETED COVER.
- F. METAL FLOOR BOXES: CAST METAL, FULLY ADJUSTABLE, RECTANGULAR.
- G. SMALL METAL RACKS: GALVANIZED STEEL WITH SNAP-ON COVERS. MANUFACTURER'S STANDARD ENAMEL FINISH IN COLOR SELECTED BY ARCHITECT.
- H. CAST-METAL ACCESS, FULL, AND JUNCTION BOXES: NEMA FB 1, GALVANIZED, CAST IRON WITH GASKETED COVER.
- I. Hinged-Cover Enclosures: NEMA 250, Type 1, WITH CONTINUOUS-ROUNDED COVER WITH FLUSH LATCH, UNLESS OTHERWISE INDICATED.
 - 1. METAL ENCLOSURES: STEEL, FINISHED INSIDE AND OUT WITH MANUFACTURER'S STANDARD ENAMEL.
 - 2. IN STANDARD PARTITIONS, WHERE 1/2" AND 3/4" COATS ARE EMPLOYED: 4" SQUARE BY 2-1/2" DEEP BOXES WITH 1-GANG OR 2-GANG PLASTER COVERS SHALL BE USED, NO. 45-SPR.
 - 3. 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-SPR.
 - 4. IN STANDARD PARTITIONS, WHERE COATS 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. 45-SPR.
 - 5. IN STANDARD PARTITIONS, WHERE COATS 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. 45-SPR.
 - 6. WHERY 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.
- J. CABINETS:
 - 1. NEMA 250, TYPE 1, GALVANIZED-STEEL BOX WITH REMOVABLE INTERIOR PANEL AND REMOVABLE FRONT, FINISHED INSIDE AND OUT WITH MANUFACTURER'S STANDARD ENAMEL.
 - 2. HINGED DOOR IN FRONT COVER WITH FLUSH LATCH AND CONCEALED HINGE.
 - 3. KEY LATCH TO MATCH PANELBOARDS.
 - 4. METAL BARRIERS TO SEPARATE WIRING OF DIFFERENT SYSTEMS AND VOLTAGE.
 - 5. NECESSARY FEET WELDS REQUIRED FOR PRESTRESSING EQUIPMENT.
- K. RACEWAY APPLICATION:
 - 1. EXPOSED CONDUIT: RIDG STEEL CONDUIT.
 - 2. CONCEALED CONDUIT, ABOVEGROUND: RIDG STEEL CONDUIT, EMT, RMC, UNDERGROUND CONDUIT, PVC, TYPE EPC-40-PVC, DIRECT BURIED.
 - 3. CONNECTION TO VIBRATING EQUIPMENT (INCLUDING TRANSFORMERS AND HYDRAULIC, PNEUMATIC, ELECTRIC SOLENOID, OR MOTOR-DRIVEN EQUIPMENT): LFWC.
 - 4. BOXES AND ENCLOSURES: APPROVED: NEMA 250, TYPE 3E.
 - 5. COMPLY WITH THE FOLLOWING INDOOR APPLICATIONS, UNLESS OTHERWISE INDICATED:
 - 1. EXPOSED, NOT SUBJECT TO SEVERE PHYSICAL DAMAGE: EMT.
 - 2. EXPOSED, NOT SUBJECT TO SEVERE PHYSICAL DAMAGE: RIDG STEEL CONDUIT.
 - 3. EXPOSED AND SUBJECT TO SEVERE PHYSICAL DAMAGE: RIDG STEEL CONDUIT, INCLUDES 3/4 INCHES IN THE FOLLOWING LOCATIONS: LOADING DOCK, CORRIDORS USED FOR TRAFFIC OF MECHANIZED CARTS, FORKLETS, AND PALLET-HANDLING UNITS, MECHANICAL ROOMS, CONCEALED IN CEILING AND INTERIOR WALLS AND PARTITIONS: EMT.
 - 4. CONNECTION TO VIBRATING EQUIPMENT (INCLUDING TRANSFORMERS AND HYDRAULIC, PNEUMATIC, ELECTRIC SOLENOID, OR MOTOR-DRIVEN EQUIPMENT): FMC, EXCEPT USE LFWC IN DAMP OR WET LOCATIONS.
 - 5. DAMP OR WET LOCATIONS: RIDG STEEL CONDUIT.
 - 6. RACEWAYS FOR OPTICAL FIBER OR COMMUNICATIONS CABLE RISERS IN VERTICAL SHAFTS: RISER-TYPE, OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY, EMT.
 - 7. RACEWAYS FOR CONCEALED GENERAL PURPOSE DISTRIBUTION OF OPTICAL FIBER OR COMMUNICATIONS CABLE: GENERAL-PURPOSE, OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY, RISER-TYPE, OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY, FLEMUM-TYPE, OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY, EMT.
 - 8. BOXES AND ENCLOSURES: NEMA 250, TYPE 1, EXCEPT USE NEMA 250, TYPE 4K, STAINLESS STEEL IN DAMP OR WET LOCATIONS.
 - 9. MINIMUM RACEWAY SIZE: 1-1/2-INCH (38-MM) TRADE SIZE.
 - 10. RACEWAY FITTINGS: COMPATIBLE WITH RACEWAYS AND SUITABLE FOR USE AND LOCATION.
 - 11. RIDG AND INTERMEDIATE STEEL CONDUIT: USE THREADED RIDG STEEL CONDUIT FITTINGS, UNLESS OTHERWISE INDICATED.
 - 12. PVC EXTERNALLY COATED, RIDG STEEL CONDUITS: USE ONLY FITTINGS LISTED FOR USE WITH THAT MATERIAL. PATCH AND SEAL ALL JOINTS, NICKS, AND SCRAPES IN PVC COATING AFTER INSTALLING CONDUITS AND FITTINGS. USE SEALANT RECOMMENDED BY FITTING MANUFACTURER.
- L. INSTALLATION: COMPLY WITH NECA 1 FOR INSTALLATION REQUIREMENTS APPLICABLE TO PRODUCTS SPECIFIED EXCEPT WHERE REQUIREMENTS ON DRAWINGS OR IN THIS ARTICLE ARE STRICTER.
 - 1. 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.
 - 2. COMPLETE RACEWAY INSTALLATION BEFORE STARTING CONDUITOR INSTALLATION.
 - 3. AC SUPPORT RACEWAYS AS SPECIFIED IN "HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS." 4. ARRANGE STUB-UPS SO CURVED PORTIONS OF BENDS ARE NOT VISIBLE ABOVE THE FINISHED SLAB.
 - 5. INSTALL NO MORE THAN THE EQUIVALENT OF THREE 90-DEGREE BENDS IN ANY SINGLE RUN EXCEPT FOR COMMUNICATIONS CONDUITS FOR WHICH FIBER BENDS ARE ALLOWED.
 - 6. CONCEAL CONDUIT AND EMT WITHIN FINISHED WALLS, CEILING, AND FLOORS, UNLESS OTHERWISE INDICATED.
 - 7. 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 SPRING FITTING METHOD.
 - 3. CHANGE FROM EMT TO RMC, TYPE EPC-40-PVC, RIDG STEEL CONDUIT, OR IMC BEFORE RISING ABOVE THE FLOOR.
 - 8. 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 COMPANION MANUFACTURER'S WRITTEN INSTRUCTIONS.
 - 9. RACEWAY TERMINATIONS AT LOCATIONS SUBJECT TO MOISTURE OR VIBRATION: USE RELATING BUSHINGS TO PROTECT CONDUITS, INCLUDING CONDUITS SMALLER THAN NO. 4 AWG.
 - 10. INSTALL PULL WIRES IN EMPTY RACEWAYS: USE POLYPROPYLENE OR MONOPOLYMER 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.
 - 11. RACEWAYS FOR OPTICAL FIBER AND COMMUNICATIONS CABLE: INSTALL RACEWAYS, METALLIC AND NONMETALLIC, RIDG 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 LISTS WITH FULL OR JUNCTION BOXES OR TERMINATIONS AT DISTRIBUTION FRAMES OR CABINETS WHERE NECESSARY TO COMPLY WITH THESE REQUIREMENTS.
- M. 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 COOL LOCATIONS, SUCH AS BOUNDARIES OF REFRIGERATED SPACES.
 - 2. WHERE REQUIRED BY NECA 70.

TRANSFORMERS

- A. SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:
 - 1. EATON ELECTRICAL INC.; OUTLETS-HAMMER PRODUCTS.
 - 2. GENERAL ELECTRIC COMPANY.
 - 3. SIEMENS ENERGY & AUTOMATION, INC.
 - 4. SOLAHEW-DUTY.
 - 5. SQUARE D; SCHNEIDER ELECTRIC.
- B. GENERAL TRANSFORMER REQUIREMENTS:
 - DESCRIPTION: FACTORY-ASSEMBLED AND -TESTED, AIR-COOLED UNITS FOR 60-HZ SERVICE. GRAN-ORIENTED, NON-MAGN SILICON STEEL. CONTINUOUS WINDINGS WITHOUT SPLICES EXCEPT FOR TAPS. INTERNAL COIL CONNECTIONS: BRAZED OR PRESSURE TIE. COIL MATERIAL: COPPER.
- C. COMPLY WITH NEMA ST 20, AND LIST AND LABEL AS COMPLYING WITH UL 1561, ONE LEO PER PHASE.
- D. ENCLOSURE: VENTILATED, NEMA 250, TYPE 2. CORE AND COIL SHALL BE ENCAPSULATED WITHIN RESIN COMPOUND, SEALING OUT MOISTURE AND AIR.
- E. ENCLOSURE: VENTILATED, NEMA 250, TYPE 3R. CORE AND COIL SHALL BE ENCAPSULATED WITHIN RESIN COMPOUND, SEALING OUT MOISTURE AND AIR.
- F. TRANSFORMER ENCLOSURE FINISH: COMPLY WITH NEMA 250, FINISH COLOR: GRAY.
- G. TAPS FOR TRANSFORMERS SMALLER THAN 7.5 KVA: ONE 5 PERCENT TAP ABOVE NORMAL FULL CAPACITY.
- H. TAPS FOR TRANSFORMERS 7.5 TO 24 KVA: ONE 5 PERCENT TAP ABOVE AND ONE 5 PERCENT TAP BELOW NORMAL FULL CAPACITY.
- I. TAPS FOR TRANSFORMERS 25 KVA AND LARGER: TWO 2.5 PERCENT TAPS ABOVE AND TWO 2.5 PERCENT TAPS BELOW NORMAL FULL CAPACITY.
- J. INSULATION CLASS: 220 DEG C, UL-COMPONENT-NEUTRATED INSULATION SYSTEM WITH A MAXIMUM OF 115 DEG C RISE ABOVE 40 DEG C AMBIENT TEMPERATURE.
- K. ENERGY EFFICIENCY FOR TRANSFORMERS RATED 15 KVA AND LARGER: COMPLYING WITH DOE-2016 10 CFR PART 431.
- L. K-FACTOR RATING: TRANSFORMERS INDICATED TO BE K-FACTOR RATED SHALL COMPLY WITH UL 1561 REQUIREMENTS FOR NONSOLID-STATE LOAD CURRENT-HOLDING CAPABILITY TO THE DEGREE DEFINED BY DESIGNATED K-FACTOR. INTERNAL SHUNT OVERHEAT HAVING CARRYING FULL-LOAD CURRENT WITH HARMONIC DISTORTION CORRESPONDING TO DESIGNATED K-FACTOR. INDICATE VALUE OF K-FACTOR ON TRANSFORMER NAMEPLATE.
- M. ELECTROSTATIC SHIELDING: EACH WINDING SHALL HAVE AN INDEPENDENT, SINGLE, FULL-WIDTH COPPER TERMINAL STRIPS TO MINIMIZE CAPACITIVE COUPLING BETWEEN INPUT AND OUTPUT TERMINALS, INCLUDE SHIELD TERMINAL FOR SHIELDING EFFECTIVENESS. CAPACITIVE COUPLING BETWEEN PRIMARY AND SECONDARY WINDINGS: NOT TO EXCEED 33 PERCENT ABOVE A FREQUENCY RANGE OF 20 HZ TO 1 MHz. COMMON-MODE NOISE ATTENUATION: MINIMUM OF MINUS 10 DB TO 15.5 DB AT 1.5 TO 10 KHZ. COMMON-MODE NOISE ATTENUATION: MINIMUM OF MINUS 52 DBA AT 1.5 TO 10 KHZ.
- N. FUNGUS PROOFING: PERMANENT FUNGICIDAL TREATMENT FOR COIL AND CORE.
- O. LUG RATING: ALL LUG CONNECTIONS SHALL BE RATED FOR CONNECTION OF 75 DEG C INSULATION CONDUCTORS.

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 CLAMPS. 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: PANELS AND TRIM: GALVANIZED STEEL, FACTORY FINISHED, BASED ON FINISH CLEANING AND PRETREATING WITH MANUFACTURER'S STANDARD TWO-COAT, IMBED-ON FINISH CONSISTING OF PRIME COAT AND THERMOSETTING TOPCOAT.
- 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: MATERIAL: TIN-PLATED ALUMINUM OR HARD-DRAWN COPPER, 98 PERCENT CONDUCTIVITY. EQUIPMENT BUSES: ADEQUATE FOR FEEDER AND BRANCH-CIRCUIT EQUIPMENT GROUNDING CONDUCTORS; BONDED TO BOX.
- J. CONDUCTOR CONNECTIONS: 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-TROUGH LUGS: COMPRESSION TYPE, SUITABLE FOR USE WITH CONDUCTOR MATERIAL. LOCATE AT OPPOSITE END OF BUS FROM INCOMING LUGS OR MAIN DEVICES, 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 MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:
 - 1. EATON ELECTRICAL INC.; CUTLER-HAMMER BUSINESS UNIT.
 - 2. GENERAL ELECTRIC COMPANY; GE CONSUMER & INDUSTRIAL.
 - 3. SIEMENS ENERGY & AUTOMATION, INC.
 - 4. SQUARE D; A BRAND OF SCHNEIDER ELECTRIC.
- M. PANELBOARDS: NEMA 1E 1 LIGHTING AND APPLIANCE BRANCH-CIRCUIT TYPE. MAINS: CIRCUIT BREAKER OR FUSE. OVERCURRENT PROTECTIVE DEVICES: BRANCH OVERCURRENT PROTECTIVE DEVICES: BOTH ON-CIRCUIT BREAKERS, REPLACEABLE WITHOUT DISTURBING ADJACENT UNITS. DOORS: CONCEALED HINGES; SECURED WITH FLUSH LATCH WITH TUMBLER LOCK, KEYPAD ALIKE.

LIGHTING FIXTURES

- A. GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS:
 - 1. RECESSED FIXTURES: COMPLY WITH NEMA LE 4 FOR WELDER COMPATIBILITY FOR RECESSED FIXTURES.
 - 2. INCANDESCENT FIXTURES: COMPLY WITH UL 1598, WHERE LER IS SPECIFIED, TEST ACCORDING TO NEMA LE 5A.
 - 3. FLUORESCENT FIXTURES: COMPLY WITH UL 1598, WHERE LER IS SPECIFIED, TEST ACCORDING TO NEMA LE 5 AND NEMA LE 5A AS APPLICABLE.
 - 4. LED FIXTURES:
 - 4.1. LISTED AND LABELED AS DEFINED IN NFPA 70, BY A QUALIFIED TESTING AGENCY, AND MARKED FOR INTENDED LOCATION AND APPLICATION.
 - 4.2. EACH LUMINAIRE TYPE SHALL BE BINNED WITHIN A THREE-STEP MACADAM ELLIPSE OF DIFFERENT COLOR CONSISTENCY AMBARIES.
- B. 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 REASSEMBLY WITHOUT USE OF TOOLS, DESIGNED TO PREVENT DOORS, FRAMES, DEFENSES, DIFFUSERS, AND OTHER COMPONENTS FROM FALLING ACCIDENTALLY DURING RELAXING AND WHEN SECURED IN OPENING POSITION.
- C. LAMP TYPES AND GLOBES:
 - 1. ACRYLIC LIGHTING DIFFUSERS: 100 PERCENT VIRGIN ACRYLIC PLASTIC, HIGH RESISTANCE TO YELLOWING AND OTHER CHANGES DUE TO AGING, RESISTIVE 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.
- D. 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 INSTRUCTIONS FOR 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 FLUORESCENT AND COMPACT FLUORESCENT 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 FLUORESCENT AND COMPACT FLUORESCENT LUMINAIRES.
 - 5. ANSI BASE TEST TYPE (MR8, M57, ETC.) FOR HID LUMINAIRES.
 - 6. OCT AND ORF FOR ALL LUMINAIRE TYPES.
- E. ELECTROMAGNETIC-INTERFERENCE FILTERS: FACTORY INSTALLED TO SUPPRESS CONDUCTED ELECTROMAGNETIC INTERFERENCE. FABRICATED LIGHTING FIXTURES WITH ONE FILTER ON EACH BALLAST INDICATED TO REQUIRE A FILTER.

BALLASTS

- A. BALLASTS FOR LINEAR FLUORESCENT 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 B-LEVEL CONTROL IS INDICATED.
 - 4. SOUND RATING: CLASS A.
 - 5. TOTAL HARMONIC DISTORTION RATING: LESS THAN 10 PERCENT.
 - 6. TRANSIENT VOLTAGE PROTECTION: IEEE C62.41.1 AND IEEE C62.41.2, CATEGORY A OR B.
 - 7. OPERATING FREQUENCY: 42 KHZ OR HIGHER.
 - 8. LAMP CURRENT CREST FACTOR: 1.7 OR LESS.
 - 9. BF: 0.85 OR HIGHER.
 - 10. POWER FACTOR: 0.95 OR HIGHER.
 - 11. PARALLEL LAMP CONNECTIONS: MINIMUM LAMP BALLASTS SHALL COMPLY WITH ANSI C82.11 AND SHALL BE CONSIDERED TO MAINTAIN FULL LIGHT OUTPUT ON SURVIVING LAMPS IF ONE OR MORE LAMPS FAIL.
- B. LUMINAIRE'S 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.
- D. ELECTROMAGNETIC BALLASTS: COMPLY WITH ANSI C82.1; ENERGY SAVING, HIGH-POWER FACTOR, CLASS P, AND HAVING AUTOMATIC-RESET THERMAL PROTECTION.
- E. BALLAST MANUFACTURER CERTIFICATION: INDICATED BY LABEL.
- F. SINGLE BALLASTS FOR MULTIPLE LIGHTING FIXTURES: FACTORY WIRED WITH BALLAST ARRANGEMENTS AND BUNDLED EXTENSION WIRING TO SUIT FINAL INSTALLATION CONDITIONS WITHOUT MODIFICATION OR REWIRING IN THE FIELD.
- G. BALLASTS FOR COMPACT FLUORESCENT LAMPS:
 - 1. LAMP END-OF-LIFE DETECTION AND SHUTDOWN CIRCUIT.
 - 2. AUTOMATIC LAMP STARTING AFTER LAMP REPLACEMENT.
 - 3. SOUND RATING: CLASS A.
 - 4. TOTAL HARMONIC DISTORTION RATING: LESS THAN 20 PERCENT.
 - 5. TRANSIENT VOLTAGE PROTECTION: IEEE C62.41.1 AND IEEE C62.41.2, CATEGORY A OR B.
 - 6. OPERATING FREQUENCY: 20 KHZ OR HIGHER.
 - 7. LAMP CURRENT CREST FACTOR: 1.7 OR LESS.
 - 8. BF: 0.95 OR HIGHER UNLESS OTHERWISE INDICATED.
 - 9. POWER FACTOR: 0.95 OR HIGHER.
 - 10. INTERFERENCE: COMPLY WITH 47 CFR 18, CH 1, SUBPART C, FOR LIMITATIONS ON ELECTROMAGNETIC AND RADIO-FREQUENCY INTERFERENCE FOR NONCONSUMER EQUIPMENT.

FLUORESCENT LAMPS

- A. T8 RAPID-START LAMPS, RATED 32 W MAXIMUM, NOMINAL LENGTH OF 48 INCHES (1220 MM), 2000 INITIAL LUMENS (MINIMUM), OR 85 (MINIMUM, COLOR TEMPERATURE 3000 K, AND AVERAGE RATED LIFE OF 20,000 HOURS UNLESS OTHERWISE INDICATED).
- B. T8 RAPID-START LAMPS, RATED 17 W MAXIMUM, NOMINAL LENGTH OF 24 INCHES (610 MM), 1300 INITIAL LUMENS (MINIMUM), OR 85 (MINIMUM, COLOR TEMPERATURE 3000 K, AND AVERAGE RATED LIFE OF 20,000 HOURS UNLESS OTHERWISE INDICATED).
- C. T5 RAPID-START LAMPS, RATED 28 W MAXIMUM, NOMINAL LENGTH OF 45.2 INCHES (1150 MM), 2000 INITIAL LUMENS (MINIMUM), OR 85 (MINIMUM, COLOR TEMPERATURE 3000 K, AND AVERAGE RATED LIFE OF 20,000 HOURS UNLESS OTHERWISE INDICATED).
- D. T5HO RAPID-START HIGH-OUTPUT LAMPS, RATED 40 W MAXIMUM, COLOR TEMPERATURE 3000 K, AVERAGE RATED LIFE OF 10,000 HOURS AT THREE HOURS OPERATION PER START, AND SUITABLE FOR USE WITH DIMMING BALLASTS UNLESS OTHERWISE INDICATED.
 - 1. 13 W: T4, DOUBLE OR TRIPLE TUBE, RATED 1200 INITIAL LUMENS (MINIMUM).
 - 2. 18 W: T4, DOUBLE OR TRIPLE TUBE, RATED 1200 INITIAL LUMENS (MINIMUM).
 - 3. 26 W: T4, DOUBLE OR TRIPLE TUBE, RATED 1800 INITIAL LUMENS (MINIMUM).
 - 4. 32 W: T4, TRIPLE TUBE, RATED 2400 INITIAL LUMENS (MINIMUM).
 - 5. 42 W: T4, TRIPLE TUBE, RATED 3200 INITIAL LUMENS (MINIMUM).
 - 6. 57 W: T4, TRIPLE TUBE, RATED 4300 INITIAL LUMENS (MINIMUM).
 - 7. 70 W: T4, TRIPLE TUBE, RATED 5200 INITIAL LUMENS (MINIMUM).

LED LAMPS

- A. MINIMUM LUMENS PER SCHEDULED FIXTURE.
- B. MINIMUM ALLOWABLE EFFICACY OF 85 LM/W.
- C. CRI OF MINIMUM 90. CRI PER SCHEDULED FIXTURE.
- D. LAMP LIFE OF 50,000 HOURS. LAMP LIFE OF THE DEVICE AND WITH INHERENT ELECTRICAL ISOLATION FROM 100 PERCENT TO 1 PERCENT OF MAXIMUM LIGHT OUTPUT.
- E. INTERNAL DRIVER.
- F. USER-REPLACEABLE LAMPS:
 - 1. BULB SHAPE COMPLYING WITH ANSI C81.01 OR IEC 60061-1.
 - 2. LAMP BASE COMPLYING WITH ANSI C81.01 OR IEC 60061-1.

WIRING DEVICES

- A. MANUFACTURERS:
 - 1. COOPER WIRING DEVICES.
 - 2. HUBBELL INCORPORATED; WIRING DEVICE-KELLUMS.
 - 3. LEVITON USA COMPANY.
 - 4. PASS &