	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 05 00 Conductors and Cables
		Date: 8/1/17
		Author: Office of Facilities
CC: Project Folder		

Change History


Date	Description of Change	Pages / Sections Modified	Change Approver Initials
8/1/17	Updated section on Manufacturers	3 – 1.	SO
6/15/16	Updated division section from 16120 to 26 05 00, removed references to other section numbers	-	mgl44
11/21/14	Amend manufacturer list for current sources	4 – 16120, E. 1. (Conductors and Cables; Manufacturers)	SO
10/17/14	Add supporting paragraph 11.	6 – 16120, F. #11 (Conductors and Cables; Materials)	SO
3/26/13	Add two manufacturers to list	4 - 16120, E. #1 (Conductors and Cable; Manufacturers)	SO
3/26/13	Amend Materials paragraphs to avoid use of PVC thermoplastic jacketing and insulation compounds in favor of non PVC thermoset compounds.	5 - 16120, F. #1, #2, #3, #4 & #8 (Conductors and Cable; Materials)	SO
3/26/13	Add at end of text to paint Fire Alarm conduit red.	8 - 16120 H. #8 (Conductors and Cable; Installation Guidelines)	SO
6/14/13	Amend manufacturer list for updated parent company name (BICC is now General Cable) and fix alpha order.	4 – 16120 E. #1 (Conductors and Cable; Manufacturers)	SO

A. Summary

This section contains design criteria for building wire and cable, flexible cords, connecting devices, and related materials for use on systems below 600 volts.

B. System Design and Performance Requirements


- For power and lighting systems, use single-conductor stranded wires installed in conduit, whenever possible. Use cables only if FMC is unsuitable due to size or other restrictions. However, cables may be specified in the tenant spaces of Yale University Investments Office properties when permitted by the Yale University Project Manager.
- Except for special situations, such as excessive voltage drop or a high ambient environment, the minimum wire size for power and lighting branch circuits is #12 AWG. The minimum wire size for control circuits is #14 AWG. In instances where the length of the control circuit (measured from source to operating device) exceeds 250 feet, the minimum wire size is #12 AWG.
- Where single conductors are used for fire alarm systems, the minimum wire sizes are #16 AWG for initiation circuits and #14 AWG for signal circuits.
- Specify insulated equipment grounding conductors for all conduits containing circuits operating at over 50 volts to ground.

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5. Base conductor ampacities on 75°C ratings, unless required connections are rated at 90°C. All conductors shall be copper.
6. For voltage drop calculations, assume a nominal system voltage at the building service entrance with all connected loads energized. Where certain loads cannot operate simultaneously, the smaller load may be omitted from the calculations. Minimum voltages with a full connected load energized are:
 - At all panelboards—98 percent of nominal voltage
 - At all utilization equipment—95 percent of nominal voltage or no more than 3 percent of nominal voltage from panelboard
7. Ensure that branch circuits supplying personal computers and other equipment generating harmonics in the grounded circuit conductor are run with individual neutral. Where individual neutrals cannot be provided due to raceway size restrictions, multiwire branch circuits may be provided with neutral conductor ampacity sized at 200 percent of the setting of the overcurrent protective device **or** with neutral conductor sized at 200 percent of the size of phase conductor whichever is higher. Where one-third or more of the connected load or anticipated future load on a feeder consists of such equipment, ensure that feeder neutrals are similarly oversized. Where the size of ungrounded conductors is increased due to voltage drop, increase neutral size accordingly.
8. Ensure that feeder schedules shown on construction documents are in accordance with Section 01064: Electrical Regulatory and Directive Standards.
9. Ensure that EM&C system control wiring provided under Division 16 includes the following:
 - Wiring from the power source to the Direct Digital Control (DDC) panels
 - Wiring from remote input points to the DDC panels
 - Wiring from the DDC panels to controlled output devices
 - Wiring from DDC panels to the telephone system connection for communication with the central system
10. On the Central and Science Campuses, ensure that all EM&C control wiring is compatible with the Johnson Controls "Metasys" system.
11. On the Medical School Campus, ensure that all EM&C control wiring is compatible with the Robertshaw Controls "DMS350A" system.

C. Submittals

Submit wiring diagrams showing point-to-point interconnections and terminations, cabling,

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identification schemes, logic diagrams, switch settings, and jumper positions.


D. Product Standards

Ensure that all products conform to the following standards:

- ICEA S-19-81, Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
- ICEA S-61-402, Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
- UL 62, Flexible Cord and Fixture Wire
- UL 83, Thermoplastic-Insulated Wires and Cables
- UL 310, Electric Quick-Connect Terminals
- UL 486A, Wire Connectors and Soldering Lugs for Use with Copper Conductors
- UL 486C, Splicing Wire Connectors
- UL 486E, Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
- UL 510, Insulating Tape
- UL 1059, Electrical Terminal Blocks
- Johnson Controls, Metasys Design Manual
- Robertshaw Controls, Electronics Products Master Catalog


E. Manufacturers

1. Subject to compliance with the design requirements, provide 600 V cables by one of the following manufacturers:
 - Belden Wire and Cable (for instrumentation and communications)
 - Cerro
 - Chromalox
 - Dekoron Wire and Cable (for instrumentation and communications)
 - General Cable
 - Nelson
 - Rockbestos
 - ShawFlex

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F. Materials

1. Use only single-conductor, insulated, stranded copper cables, cords, or building wire. Use flame-retardant, dual-rated, type XHHW-2, 600 volts conductor insulation rated at 75°C in wet locations and 90°C in dry locations. The insulation must be labeled as Gasoline and Oil Resistant II.
2. Use the following stranded copper wiring for control systems and fire alarm systems that use single conductors in conduit:
 - #14 AWG: Type XHHW-2, 600 volts, 19 strands
 - #16 AWG: Type SF-1, SFF-1 or SFF-2, 300 volts, 7 strands
 - #18 AWG: Type SF-1, SFF-1 or SFF-2, 300 volts, 7 strands
3. Where permitted, use type MC cables with type XHHW-2 copper conductors and an insulated grounding conductor contained within an interlocked steel sheath constructed with integral bonding wire so that sheath is also suitable for grounding.
4. Where specified use type STOO flexible cords with type XHHW-2 conductors and an insulated grounding conductor.
5. Make connections other than terminations at equipment lugs as follows. Connecting devices requiring solder are not acceptable.
 - Feeders—copper compression connectors or tin-plated copper power distribution blocks
 - Branch circuits—insulated spring wire connectors
 - Control circuits—tin-plated copper fork or ring terminals, quick-connect terminals, or terminal blocks
6. For instrument cables single or multi paired, use shielded, twisted pairs of #18 AWG stranded copper conductors, with 300 volt insulation, contained in blue teflon jackets. Unless completely installed in conduit, all cables must be plenum rated. Cables must be 2-, 3-, or 4-conductor, as required by specific design conditions.
7. Use Anixter #889315 pre-made cables to connect temperature sensors ("metastats") to the telephone system, including 25 feet of 8-conductor plenum cable and RJ45 connectors.
8. Use #14 AWG, type XHHW-2 wiring on 120 VAC systems to provide power for EM&C system control panels and control devices, such as actuators, freezestats, and starters. If circuits have 20 amp breakers then wiring shall be #12 AWG.

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9. Wiring in the plenums shall be rated for the area. Type AC cable or other factory assembled multi-conductor cable of metallic wiring systems with no nonmetallic sheath shall not be used in plenum areas. Other types of cables and conductors have to be installed in electrical metallic tubing, metal conduit, metal wireway, or solid metal tray. All cables shall be listed as having adequate fire-resistant and low smoke-producing characteristics.
10. The use of MC cable shall only be from a branch junction box to single branch device. Branch circuits home runs with MC cable is not permitted.
11. For normal and alternate service where the wire run outdoor, both within a manhole or duct bank, the wire shall have a low smoke, zero halogen (LSZH) outer jacket. The wire insulation can be XLPE but have the LSZH jacket. All wiring in the manhole shall be fire wrapped including the 480V wires.

G. Preparation

1. Comply with the following color-coding requirements for power and lighting circuits:
 - Single phase systems—black for line 1, white for the grounded circuit conductor, green for the equipment grounding conductor.
 - Three phase systems, 208Y/120 volts—black for phase A, red for phase B, blue for phase C, white for neutral, green for ground.
 - Three phase systems, 480Y/277 volts—brown for phase A, orange for phase B, yellow for phase C, gray for neutral, green for the ground.
 - Three phase systems, 480 volts—same as 480Y/277 volts, except no gray for neutral.
 - Isolated ground systems shall be green with yellow tracer for isolated ground conductor.
2. On conductors #8 AWG and larger, black insulation may be used for all phases if colored, pressure-sensitive plastic tape is applied at all terminations in half- overlapping turns for three inches, with last two laps of tape applied with no tension to prevent unwinding.

H. Installation Guidelines

1. With the following exceptions, run all wiring in conduit or other raceway.
 - Where flexibility is required and FMC is unsuitable due to size or other restrictions, type MC cable may be used. Type MC cable may be used only for device drops.
 - Final connections to exterior floodlights may be made with type STOO flexible cord.
 - Such items as pendent pushbutton stations and cord connectors may be made with type

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STOO flexible cord.

- Cabling for fire alarm, intrusion detection, access control, public address, closed circuit television, HVAC control, energy management control, and similar systems, may be run without raceways where permitted by the Yale University Project Manager.
2. Run conductors of different systems in separate raceways. Do not run systems above 250 volts in raceways with systems below 250 volts. Each type of system below 50 volts (controls, public address, access control) is considered an individual system to be provided with dedicated raceways. Do not run conductors serving emergency systems, such as emergency lighting, with conductors of any other systems. Do not run circuits fed from the alternate service system with circuits fed from the normal service system.
 3. Include the following requirement in specifications: Where #10 AWG and smaller conductors pass through boxes without termination or splice, loop the conductors once within the box to provide adequate slack should future connections become necessary.
 4. Use wire basket grip strain relief devices for all flexible cord terminations.
 5. Identify all junction boxes serving EM&C systems by painting the covers blue, as described in Division 9, Finishes.
 6. Ensure that color-coding and numbering of individual wires is in accordance with Division 15 requirements.
 7. Communication cables or coaxial cables shall be marked in accordance with the requirement of NEC 800.113 or NEC 820.113 respectively.
 8. Fire alarm systems wiring shall be run in conduit. All fire alarm system conduit to be painted red.

I. Quality Control

Perform insulation resistance testing for all #3/0 and larger feeders, and submit the results to Yale University.

End of Section