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MAXIMUM USABLE AREA OF THE CONDUIT

The IMSA Level II traffic signal manual provides basic information on NEC conduit fill requirements indicating that, for more than 2 conductors in a single conduit, the conductors cannot occupy more than 40% of the cross-sectional area of the conduit (from Chapter 9, Table 1 of the NEC). But exactly how does one go about determining whether or not this criterion is met for a given installation? The following example shows how this is done:

EXAMPLE

The design of a particular traffic signal calls for 7 loops and 2 pedestrian heads located on the northeast corner of the intersection to be connected to the controller cabinet situated on the same corner via a 100 foot stretch of 2" Rigid Schedule 40 PVC conduit. State specifications require the use of AWG #14 lead-in cable (IMSA Spec. 50-2) for the loops and AWG #12 signal cable (IMSA Spec. 20-1) for the pedestrian heads. If the contractor uses 9-conductor signal cable to serve the pedestrian head, can all of the cables be accommodated within this single conduit without violating the NEC?

STEP 1: Calculate the cross-sectional area of the conduit. Oddly enough, the nominal size of a conduit is always slightly different than it's true inside diameter. In this example, the 2-inch PVC conduit has a true inside diameter of 2.047 inches and a corresponding area of 3.291 square inches (Area = Pi x Radius Squared, or: Area = 3.14 x 1.024 x 1.024 = 3.291) The true inside diameter of various conduits is presented in Chapter 9, Table 4 of the NEC. The reader is cautioned to use this table carefully since there are subtle distinctions between the various table headings. For instance, the dimensions for 4 different types of PVC conduits are provided in this table (Schedule 40, Schedule 80, Type A, and Type EB). Make sure you pick the right one.

STEP 2: Treat multiconductor cables as a single conductor. Note 9 of Table 1 of the NEC states that a multiconductor cable shall be treated as a single conductor for conduit fill calculations. Consequently, each loop lead-in cable, which has two conductors, is treated as a single conductor. Likewise, the 9-conductor signal cable is also treated as a single conductor. We therefore have 8 conductors, not 23 conductors, as far as NEC fill requirements are concerned. Since this is more than 2 conductors, the 40% maximum fill criterion applies.

STEP 3: Calculate the available cross-sectional area of the conduit. In this case, 3.291 square inches is multiplied by 40% to obtain 1.316 square inches of available area.

STEP 4: Determine the total cross-sectional area of the cables. From literature supplied by the cable manufacturer it is determined that the lead-in cable has an outside diameter of 0.340 inches while the 9-conductor signal cable has an outside diameter of 0.725 inches. These diameters yield cross-sectional areas of 0.091 square inches and 0.413 square inches, or a total of 1.050 square inches. (7 x 0.091 + 0.413)

STEP 5: Compare the total cross-sectional area of the cables to the available cross-sectional area of the conduits. Since the total cross-sectional area of the cables is less than the available cross-sectional area of the conduits, the NEC requirement is met!

If a conduit is less than 24 inches in length it is considered by the NEC to be a "nipple" and the maximum fill criterion increases to 60% regardless of the number of conductors (see Note 4 of NEC Chapter 9, Table 1.). Conduits of this length are routinely encountered in traffic signal installations between the meter base and the service disconnect. The NEC also states that, if there are any grounding conductors inside the conduit, then these conductors must also be considered when carrying-out the conduit fill calculations (see Note 3 of NEC Chapter 9, Table 1).

Whenever the plans or specifications require that conduit installation meet NEC requirements, then conduit fill calculations should be made to ensure NEC conformance.