US Army Corps
of Engineers
Afghanistan Engineer District

AED Design Requirements:
Voltage Drop Calculation Process

Various Locations,
Afghanistan

July 2010

The voltage drop of any insulated cable is dependent upon the length of the cable, the current on the cable and the impedance (ohm) per unit length of the cable based on the type of conduit.

Voltage drop on the cable shall be limited to the following:

- The voltage drop of the secondary service of 3%.
- The voltage drop of a feeder or branch circuit of 2%.

The combined voltage drop of feeder and branch circuit shall not exceed 5%.

Voltage Drop Calculations shall be provided in accordance with the NEC, regardless of where the cable was manufactured.

U.S Formula (NEC)

For three phase: **VD = 1.732 x L x R x I / 1000**
For single phase: **VD = 2 x L x R x I / 1000**

VD: The voltage drop (V)
L : The length of conductor (m)
R: The impedance value from NEC Chapter 9, Table 9 (ohm/km).
I : The load current (A)

The value R is determined from the National Electrical Code (NEC), Chapter 9, Table 9 column "Effective Z at .85 PF for Uncoated Copper" using the ohm/km column. See Table 2 below for the NEC table data presented in the USACE Allowable Capacities of Conductors chart.

Below is an example calculation for determining voltage drop.

Determine the voltage drop of a 380V, 3 phase circuit with a current of 100A and a length of 150 m and a conductor size of 50 mm in steel conduit. This is a secondary service feed.

VD = 1.732 x Length x Impedance x Current / 1000. Impedance is found in Table 2 below:
= 1.732 x 150 x 0.52 x 100 /1000
= 13.51 V

The maximum voltage drop allowed is 11.4 V. To determine the size of cable that will be required to meet the voltage drop requirement, determine the value of R that will meet the requirement.

11.4 = 1.732 x 150 x R x 100 / 1000
R = 11.4 x 1000/1.732 x 150 x 100
= 0.439 ohm/km

Referencing the NEC table (Table 2) indicates that the cable size with a voltage drop of 0.438 ohm/km or less is 1/0 AWG (70 mm)cable with a resistance of 0.43 ohm/km.

Calculating the voltage drop for the 1/0 AWG (70mm) cable results in:

VD = 1.732 x L x R x I / 1000
= 1.732 x 150 x 0.43 x 100 / 1000
= 11.17 V

The percentage voltage drop is:

Percentage Voltage Drop = 11.17 x 100 / 380 = 2.94 %

Therefore, in order to transmit a 3 phase current of 100A per phase over a length of 150 m, with a total voltage drop equal to or less than the maximum 11.4 volts, a 1/0 AWG (70 mm2) cable is needed.

This same procedure would be repeated for a feeder or branch circuit and the results added. The total voltage drop should not exceed 5%.

TABLE 2

ALLOWABLE CAPACITIES OF CONDUCTORS RATED 0 THRU 2000 VOLTS					
Not more than 3 Current-Carrying Conductors in Raceway/Cable/Earth (86°F)			Effective (Z) @ .85 PF Uncoated Copper (ohm/km)		
Size		Ampacity	Conduit Type		
AWG (Cu)	mm^2		PVC	Aluminum	Steel
12	4	20	5.60	5.60	5.60
10	6	30	3.600	3.6	3.6
8	10	40	2.260	2.26	2.3
6	16	55	1.440	1.48	1.48
4	25	70	0.950	0.95	0.98
3	35	85	0.750	0.79	0.79
2	35	89	0.620	0.62	0.66
1	50	108	0.520	0.52	0.52
1/0	70	136	0.430	0.43	0.43
2/0	70	136	0.360	0.36	0.36
3/0	95	164	0.289	0.302	0.308
4/0	120	188	0.243	0.256	0.262
250	150	216	0.217	0.230	0.24
300	150	216	0.194	0.207	0.213
350	185	245	0.174	0.190	0.197
400	240	286	0.161	0.174	0.184
500	300	328	0.141	0.157	0.164
600	300	328	0.131	0.144	0.154

Computer programs can be used to calculate the voltage drop, however the Contractor shall provide a sample hand calculation for a single feeder, branch circuit or secondary service to identify the formula that is being used to calculate voltage drop.