Table 9 Alternating-Current Resistance and Reactance for 600-Volt Cables, 3-Phase, 60 Hz, 75°C (167°F) — Three Single Conductors in Conduit															
Ohms per kilometer Ohms to neutral per 1000 feet															
	XL (Reactance) for All Wires		Alternating-Current Resistance for Uncoated Copper Wires			Alternating-Current Resistance for Aluminum Wires			Effective Z at 0.85 PF or Uncoated Copper Wires			Effective Z at 0.85 PF for Aluminum Wires			
Size (AWG or kcmil)	PVC, Aluminum Conduits	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	Size (AWG or kcmil)
14	0.190	0.240	10.2	10.2	10.2	–	–	–	8.9	8.9	8.9	–	–	–	14
	0.058	0.073	3.1	3.1	3.1	–	–	–	2.7	2.7	2.7	–	–	–	
12	0.177	0.223	6.6	6.6	6.6	10.5	10.5	10.5	5.6	5.6	5.6	9.2	9.2	9.2	12
	0.054	0.068	2.0	2.0	2.0	3.2	3.2	3.2	1.7	1.7	1.7	2.8	2.8	2.8	
10	0.164	0.207	3.9	3.9	3.9	6.6	6.6	6.6	3.6	3.6	3.6	5.9	5.9	5.9	10
	0.050	0.063	1.2	1.2	1.2	2.0	2.0	2.0	1.1	1.1	1.1	1.8	1.8	1.8	
8	0.171	0.213	2.56	2.56	2.56	4.3	4.3	4.3	2.26	2.26	2.30	3.6	3.6	3.6	8
	0.052	0.065	0.78	0.78	0.78	1.3	1.3	1.3	0.69	0.69	0.70	1.1	1.1	1.1	
6	0.167	0.210	1.61	1.61	1.61	2.66	2.66	2.66	1.44	1.48	1.48	2.33	2.36	2.36	6
	0.051	0.064	0.49	0.49	0.49	0.81	0.81	0.81	0.44	0.45	0.45	0.71	0.72	0.72	
4	0.157	0.197	1.02	1.02	1.02	1.67	1.67	1.67	0.95	0.95	0.98	1.51	1.51	1.51	4
	0.048	0.060	0.31	0.31	0.31	0.51	0.51	0.51	0.29	0.29	0.30	0.46	0.46	0.46	
3	0.154	0.194	0.82	0.82	0.82	1.31	1.35	1.31	0.75	0.79	0.79	1.21	1.21	1.21	3
	0.047	0.059	0.25	0.25	0.25	0.40	0.41	0.40	0.23	0.24	0.24	0.37	0.37	0.37	
2	0.148	0.187	0.62	0.66	0.66	1.05	1.05	1.05	0.62	0.62	0.66	0.98	0.98	0.98	2
	0.045	0.057	0.19	0.20	0.20	0.32	0.32	0.32	0.19	0.19	0.20	0.30	0.30	0.30	
1	0.151	0.187	0.49	0.52	0.52	0.82	0.85	0.82	0.52	0.52	0.52	0.79	0.79	0.82	1
	0.046	0.057	0.15	0.16	0.16	0.25	0.26	0.25	0.16	0.16	0.16	0.24	0.24	0.25	
1/0	0.144	0.180	0.39	0.43	0.39	0.66	0.69	0.66	0.43	0.43	0.43	0.62	0.66	0.66	1/0
	0.044	0.055	0.12	0.13	0.12	0.20	0.21	0.20	0.13	0.13	0.13	0.19	0.20	0.20	
2/0	0.141	0.177	0.33	0.33	0.33	0.52	0.52	0.52	0.36	0.36	0.36	0.52	0.52	0.52	2/0
	0.043	0.054	0.10	0.10	0.10	0.16	0.16	0.16	0.11	0.11	0.11	0.16	0.16	0.16	
3/0	0.138	0.171	0.253	0.269	0.259	0.43	0.43	0.43	0.289	0.302	0.308	0.43	0.43	0.46	3/0
	0.042	0.052	0.077	0.082	0.079	0.13	0.13	0.13	0.088	0.092	0.094	0.13	0.13	0.14	
4/0	0.135	0.167	0.203	0.220	0.207	0.33	0.36	0.33	0.243	0.256	0.262	0.36	0.36	0.36	4/0
	0.041	0.051	0.062	0.067	0.063	0.10	0.11	0.10	0.074	0.078	0.080	0.11	0.11	0.11	
250	0.135	0.171	0.171	0.187	0.177	0.279	0.295	0.282	0.217	0.230	0.240	0.308	0.322	0.33	250
	0.041	0.052	0.052	0.057	0.054	0.085	0.090	0.086	0.066	0.070	0.073	0.094	0.098	0.10	
300	0.135	0.167	0.144	0.161	0.148	0.233	0.249	0.236	0.194	0.207	0.213	0.269	0.282	0.289	300
	0.041	0.051	0.044	0.049	0.045	0.071	0.076	0.072	0.059	0.063	0.065	0.082	0.086	0.088	
350	0.131	0.164	0.125	0.141	0.128	0.200	0.217	0.207	0.174	0.190	0.197	0.240	0.253	0.262	350
	0.040	0.050	0.038	0.043	0.039	0.061	0.066	0.063	0.053	0.058	0.060	0.073	0.077	0.080	
400	0.131	0.161	0.108	0.125	0.115	0.177	0.194	0.180	0.161	0.174	0.184	0.217	0.233	0.240	400
	0.040	0.049	0.033	0.038	0.035	0.054	0.059	0.055	0.049	0.053	0.056	0.066	0.071	0.073	
500	0.128	0.157	0.089	0.105	0.095	0.141	0.157	0.148	0.141	0.157	0.164	0.187	0.200	0.210	500
	0.039	0.048	0.027	0.032	0.029	0.043	0.048	0.045	0.043	0.048	0.050	0.057	0.061	0.064	
600	0.128	0.157	0.075	0.092	0.082	0.118	0.135	0.125	0.131	0.144	0.154	0.167	0.180	0.190	600
	0.039	0.048	0.023	0.028	0.025	0.036	0.041	0.038	0.040	0.044	0.047	0.051	0.055	0.058	
750	0.125	0.157	0.062	0.079	0.069	0.095	0.112	0.102	0.118	0.131	0.141	0.148	0.161	0.171	750
	0.038	0.048	0.019	0.024	0.021	0.029	0.034	0.031	0.036	0.040	0.043	0.045	0.049	0.052	
1000	0.121	0.151	0.049	0.062	0.059	0.075	0.089	0.082	0.105	0.118	0.131	0.128	0.138	0.151	1000
	0.037	0.046	0.015	0.019	0.018	0.023	0.027	0.025	0.032	0.036	0.040	0.039	0.042	0.046	

Voltage drop was calculated using the formula found in 2005 NEC®, Handbook, Chapter 9, Example 2. Zc = (R x cos Θ) + (Xl x sin Θ)

NEC TABLE 9, ENGINEERING SUPERVISED CIRCUIT edited: OCT 2014

2011 NEC VOLTAGE DROP SAMPLE

DESIGNERS GUIDE

Voltage-drop calculations using the dc-resistance formula are not always accurate for ac circuits, especially for those with a less-than-unity power factor or for those that use conductors larger than 2 AWG. Table 9 allows Code users to perform simple ac voltage-drop calculations. Table 9 was compiled using the Neher-McGrath ac-resistance calculation method, and the values presented are both reliable and conservative. This table contains completed calculations of effective impedance (Z) for the average ac circuit with an 85 percent power factor (see Example 1). If calculations with a different power factor are necessary, Table 9 also contains the appropriate values of inductive reactance and ac resistance (see Example 2).

The basic assumptions and the limitations of Table 9 are as follows:

1. Capacitive reactance is ignored.
2. There are three conductors in a raceway.
3. The calculated voltage-drop values are approximate.
4. For circuits with other parameters, the Neher-McGrath ac-resistance calculation method is used.

Example 1

A feeder has a 100-ampere continuous load. The system source is 240 volts, 3 phase, and the supplying circuit breaker is 125 amperes. The feeder is in a trade size 1 1/ 4 aluminum conduit with three 1 AWG THHN copper conductors operating at their maximum temperature rating of 75°C. The circuit length is 150 ft, and the power factor is 85 percent. Using Table 9, determine the approximate voltage drop of this circuit.

Solution

Step 1. Find the approximate line-to-neutral voltage drop. Using the Table 9 column "Effective Z at 0.85 PF for Uncoated Copper Wires," select aluminum conduit and size 1 AWG copper wire. Use the given value of 0.16 ohm per 1000 ft in the following formula:

Voltage drop (line to neutral) = table value X (circuit length / 1000 ft)
X circuit load
= 0.16 ohm X (150ft / 1000ft) X 100A
= 2.40V

Step 2. Find the line-to-line voltage drop.

Voltage drop (line to line) = voltage drop (line to neutral) X 3
= 2.40V X 1.732
= 4.157V

Step 3. Find the voltage drop expressed as a percentage of the circuit voltage.

Percentage voltage drop (line to line) = (4.157V / 240V) X 100
= 1.73% VD

Step 4. Find the voltage present at the load end of the circuit.

240V – 4.157V = 235.84V

Example 2

A 270-ampere continuous load is present on a feeder. The circuit consists of a single 4 in. PVC conduit with three 600 kcmil XHHW/USE aluminum conductors fed from a 480- volt, 3-phase, 3-wire source. The conductors are operating at their maximum rated temperature of 75°C. If the power factor is 0.7 and the circuit length is 250 ft, is the voltage drop excessive?

Solution

Step 1. Using the Table 9 column "X L (Reactance) for All Wires," select PVC conduit and the row for size 600 kcmil. A value of 0.039 ohm per 1000 ft is given as this X L. Next, using the column "Alternating-Current Resistance for Aluminum Wires," select PVC conduit and the row for size 600 kcmil. A value of 0.036 ohm per 1000 ft is given as this R.

Step 2. Find the angle representing a power factor of 0.7. Using a calculator with trigonometric functions or a trigonometric function table, find the arccosine (cos –1) of 0.7, which is 45.57 degrees. For this example, call this angle . Use the table or a calculator to find the sine of 45.57 degrees, which is 0.7141.

Step 3. Find the impedance (ZC) corrected to 0.7 power factor (ZC).

Zc = (R X cos θ) + (XL X sin θ)
= (0.036 X 0.7) + (0.039 X 0.7141)
= 0.0252 X 0.0279
= 0.0531 ohm to neutral

Step 4. As in Example 1, find the approximate line-to-neutral voltage drop.

Voltage drop (line to line) = ZC X (circuit length / 1000ft) X circuit load
= 0.0530 X (250ft/1000ft) X 270A
= 3.577V

Step 5. Find the approximate line-to-line voltage drop.

Voltage drop (line to line) = voltage drop (line to neutral) X 3
= 3.577V x 1.732
= 6.196 V

Step 6. Find the approximate voltage drop expressed as a percentage of the circuit voltage.

Percentage voltage drop (line to line) = (6.196V / 480V) X 100
= 1.29%

Step 7. Find the voltage present at the load end of the circuit.

480 volts – 6.196V = 473.8V

Conclusion: According to 210.19(A)(1), FPN No. 4, this voltage drop does not appear to be excessive.