Buckeye Power Sales
Reliable Power Professionals Since 1947

Using the correct cable or wire size for any electrical application, including power generation, is a very important factor in the design of an electrical circuit, piece of electrical equipment, and any method of distributing electrical power. Since the early use of electricity in the mid-1800s, cable sizes have been standardized using the American Wire Gauge (AWG) system, which was drafted in 1857. The system was developed by J.R. Brown and Lucien Sharpe in 1856 and then adopted by American manufacturers by 1857. In subsequent years, as the electrification of the US and the world at large expanded to encompass every aspect of society, both domestic and commercial, code-setting bodies standardized the grades of cable used to conduct electricity. The NEC, a body of the National Fire Protection Association (NFPA), sets the codes for cable sizes rated for a particular amperage. This information sheet series discusses the NEC codes covering cable grading, how a specific wire size is calculated for a particular amperage, and standard wire sizes and their applications.

1.0 REGULATORY BODY SETTING POWER CABLE SIZING IN THE US:

In the US, the NEC publishes the codes for regulating power cable sizing. The NEC is a body of the NFPA, and the code referencing the standards is ANSI/NFPA 70. Across regions of the US, the NEC codes are the adopted standard for the safe installation of electrical wiring and equipment. Although not a legal requirement, local authorities enforce the NEC in their jurisdictions.

Figure 1

NEC Allowable Ampacities of Insulated Conductors

WIRE GAUGE SIZE	COPPER			ALUMINUM	
	140°F (60°C)	167°F (75°C)	194°F (90°C)	167°F (75°C)	194°F (90°C)
	NM-B	THW	THWN-2	THW	XHHW-2
	UF-B	THWN	THHN	THWN	THHN
	-	SE	XHHW-2	SE	THWN-2
		USE	-	USE	-
		XHHW		XHHW	
14	15	20	25	-	-
12	20	25	30	20	25
10	30	35	40	30	35
8	40	50	55	40	45
6	55	65	75	50	55
4	70	85	95	65	75
3	85	100	115	75	85
2	95	115	130	90	100
1		130	145	100	115
1/0		150	170	120	135
2/0		175	195	135	150
3/0		200	225	155	175
4/0		230	260	180	205
250		255	290	205	230
300		285	320	230	260
350		310	350	250	280
500		380	430	310	350
600		420	475	340	385
750		475	535	385	435
1000		545	615	445	500

Key for AWG Chart

Type	Location
TW	Wet or Dry
UF	Wet or Dry Corrosive material
RHW	Wet or Dry
THW	
THWN	
USE	
THHW	
XHHW	
RHH	Dry and Damp Locations
THHN	
XHHW	
XHH	
THHW	Dry Location
TNNW-2	Wet & Dry
XHHW-2	
THW-2	
RHW-2	

Warning: Installation of electrical wire can be hazardous if done improperly and can result in personal injury or property damage.
For safe wiring practice, consult the NEC, your building inspector, or a qualified electrician.

1.0 REGULATORY BODY SETTING POWER CABLE SIZING IN THE US (CONTINUED):

While not the law, local authorities adopt the NEC standards, in many cases, to fall in line with the Occupational Safety and Health Administration (OSHA), which is a legal body. When referencing NEC codes, the following should be noted:

1.1 LOCAL ELECTRICAL CODES – While local authorities adopt NEC codes, they can also add their own standards for wiring. Therefore, it is important to read NEC together with local wiring codes.

1.2 AUTHORITY HAVING JURISDICTION (AHJ) – AHJ is the body, like a local electrical inspector, responsible for enforcing code and ensuring compliance. The local inspector, as the AHJ, will reference NEC guidelines and any local codes.

1.3 WIRING COLOR CODES – In addition to grading power cable sizes, the NEC also sets color codes for the use of wires within an electrical circuit.

2.0 WHY THE NEC SETS REGULATIONS FOR POWER CABLE SIZING:

The primary driving factor for NEC regulations, as defined in NFPA 70, is safety. The NFPA, as the body setting codes for fire safety, is well aware that many fires are caused by faulty wiring. The following are the factors influencing power cable size:

2.1 CURRENT CARRYING CAPACITY – Any conductor carrying electrical power is made from material that also acts as a resistance to current flow. Cable wires are predominantly made from copper because copper has good conducting properties. However, in some cases, aluminum is used, which is graded separately. See information sheet: *Generator System 101 (Part 1) Ohms Law, Electrical Voltage & Conductivity.*

Heat is the result of resistance to current flow in a conductor. Excessive current will generate excessive heat if the conductor does not have the conductivity or surface area to manage the current flowing in it. Heat can cause the wire to break down its insulation and short to other cables, resulting in malfunction and possibly a fire.

2.2 VOLTAGE REGULATION – Per Ohms law voltage (V), resistance (R) and amps (I) are all related in his formula I = V/R. When the wrong-sized cable is selected, in addition to the heat being generated by the resistance, the voltage will be reduced.

Voltage reduction is the result of a cable's inability to carry a high amperage. That is why when power is transmitted over large distances, the voltage is greatly increased, and the amperage is significantly reduced to avoid excessive power loss by a drop in volts. See Information Sheet: Transformers for Power Distribution.

When designing an electrical system, the appropriate grade of wire has to be used to maintain the required voltage.

2.3 SHORT CIRCUIT RATING – To determine the correct cable grade, the system designer will also calculate the connected load current. Loads are frequently protected by circuit breakers that break the electrical flow when a certain load or short circuit is experienced. The system designer must ensure that the wiring can sustain a short-circuit current in line with the breaker's rating.

3.0 WHY WIRES ARE ASSIGNED GAUGE NUMBERS:

The NEC specifies wire gauge numbers. These numbers are set by the American Wire Gauge (AWG). The AWG number is the standard system used in the US to measure the diameter of electrical wires. The following determines the AWG number:

3.1 DIAMETER OF A WIRE – The conductor material carrying electrical power also acts as a resistance to current flow. Cable wires are predominately made from copper because copper has good conducting properties, but even copper is resistive to electrical flow. Resistance materializes as heat, and if the wire cross-sectional area is too small, the resistance and, hence, heat will exceed the limits of the wire.

3.2 CAPACITY OF THE WIRE – Over longer distances, wire size dictates voltage drop. Larger cross sections mean less drop.

4.0 INTERPRETING WIRE GAUGE NUMBERS:

The AWG numbering system has two ranges as follows:

4.1 SMALL TO MEDIUM RANGE APPLICATIONS – The AWG numbering system for wire for this range of wire sizes can appear counterintuitive, as a smaller number corresponds to a thicker wire. In comparison, a larger number indicates a thinner wire. For example, a 12-gauge wire is thicker than an 18-gauge wire.

4.2 LARGER THICKER CABLES – The AWG number for thicker, single-conductor cables used in industrial applications and large residential applications, such as service entrance cables, is larger than a 1 AWG cable gauge. Above this size, the cable is assigned an "Aught" number. There are four categories; as the number increases, it denotes a greater wire thickness, and the four numbers are 1/0, 2/0, 3/0', and 4/0 AWG.

5.0 CALCULATING REQUIRED WIRE GAUGE NUMBER:

Before consulting the wire gauge chart, see Figure 1, it is important to know the total ampere load to be connected to any wire within the electrical circuit. Power kW is a function of Amps (I) x Volts (V). First, add up the wattage of all the electrical devices that will be on the circuit. This sum is then divided by the volts of the system to give the required current or amps. When using the AWG chart, the system designer will read the amps required for both copper and aluminum (Note: Aluminum's conductivity is not as good as copper's, so wire sizes for the same amps are larger). Most charts provide several columns for various acceptable temperature rises due to wire resistance.

6.0 EXPLANATION OF WHY AN LOW AWG NUMBER IS GREATER CROSS SECTION WIRE:

Cables were originally made by pulling a red-hot metal bar through a gauge plate with a specific diameter hole. The first pull would be the number one pull. To get an even smaller cross-section of the wire, it would go through another pull to produce the next smaller diameter. This process would continue so that the smallest wire would be pulled 40 times and given a grade of 40.

To fulfill our commitment to be the leading supplier in the power generation industry, the Buckeye Power Sales team ensures they are always up-to-date with the current power industry standards as well as industry trends. As a service, our Information Sheets are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power industry.

Buckeye Power Sales
Reliable Power Professionals Since 1947

CANAL WINCHESTER, OH
8155 Howe Industrial Parkway
Canal Winchester, OH 43110
(614) 751-4515
(866) 889-2628

CINCINNATI, OH
4992 Rialto Road
West Chester, OH 45069
(513) 755-2323
(800) 368-7422

CLEVELAND, OH
8465 Tower Drive
Twinsburg, OH 44087-0394
(330) 425-9165
(800) 966-2825

TOLEDO, OH
27100 Oakmead Dr.
Perrysburg, OH 43551
(855) 638-2728

CHICAGO, IL
1308 Marquette Drive
Romeoville, IL 60446
(630) 914-3000

INDIANAPOLIS, IN
1707 S. Franklin Road
Indianapolis, IN 46239
(317) 271-9661
(800) 632-0339

FORT WAYNE, IN
7525 Maplecrest Road #221
Fort Wayne, IN 46835
(855) 638-2721

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