Choosing and Using Extension Cords

You've probably had the experience of buying a piece of equipment, opening the instructions, and finding seemingly endless paragraphs (or even pages) of safety stuff. If you're like most people, you may have glossed over that section and jumped to what you really wanted, the operating instructions.

Safety in the case of extension cords is something you should be knowledgeable about for two reasons:
- Of course, safe use reduces the chance of harm to people;
- Safe use principles also tend to be the same ones that result in less chance of damage to your equipment.

The Basic Principles: Hose Analogy

An electric cord can be compared by analogy to a garden hose. The electric current (amps) flowing through a cord is much like the water flow (gpm) flowing through a hose. The voltage (volts) to which a cord is connected is much like the pressure (psi) to which a hose is connected.

These three common-sense principles of garden hose use can help in remembering how cords work:

- Assuming no leaks, whatever water flows into one end of a hose, the same amount comes out the other end. Regardless of how long and skinny the hose is, if 3 gpm flows into one end, 3 gpm comes out the far end!

- There is a certain water pressure (psi) at the spigot to which the hose is connected. The longer or skinnier the hose, the less water pressure there will be at the far end of the hose.

- The higher the flow rate (the more gpm), the greater the pressure loss from end-to-end of the hose.

Three similar principles apply to electric cords as follows:

- Whatever current (amps) flows into one end, the same amount of current comes out the far end.

- There is a certain voltage (volts) at the point where the cord is connected to power. The longer or skinnier the cord, the less voltage there will be at the far end of the cord.

- The higher the current (amps), the greater the voltage loss from end-to-end of the cord.

Putting it another way, for every foot that water flows through a hose, there is a pressure loss. The total pressure loss for a length of hose is determined by these three factors:

1. The diameter ("size") of the hose;
2. The water flow rate;
3. The total length of the hose.

In the case of an electric cord, for every foot that current flows through a cord, there is a voltage loss. The total voltage loss for a length of cord is determined by these three factors:

1. The diameter ("size") of the copper wire;
2. The current flow rate;
3. The total length of the cord.

Applying the Three Principles to Cords

Wire size — In the U.S., the size of the copper wire inside a cord is indicated by American Wire Gauge (AWG). Cords in common use range from #18 AWG to #10 AWG. (Only even-numbered sizes are normally used.) The higher the AWG number, the smaller the wire. Here is a rough indication of uses:
#18 AWG — lamp cords (sometimes #16);
#16 AWG — a step up from lamp cords. The most commonly used general-purpose cord gauge (used for work lights, electric trimmers, etc.) Not for high-power loads.
#14 and #12 AWG — typical uses are power tools such as circular saws;
#10 AWG — large loads.

Current — Just as water flowing through a hose experiences friction and resulting pressure loss, current flowing through a wire experiences "friction" (called resistance) and resulting voltage loss. In a wire, the loss caused by the "friction" is converted into heat. The more current that flows through a wire, the warmer the wire becomes.

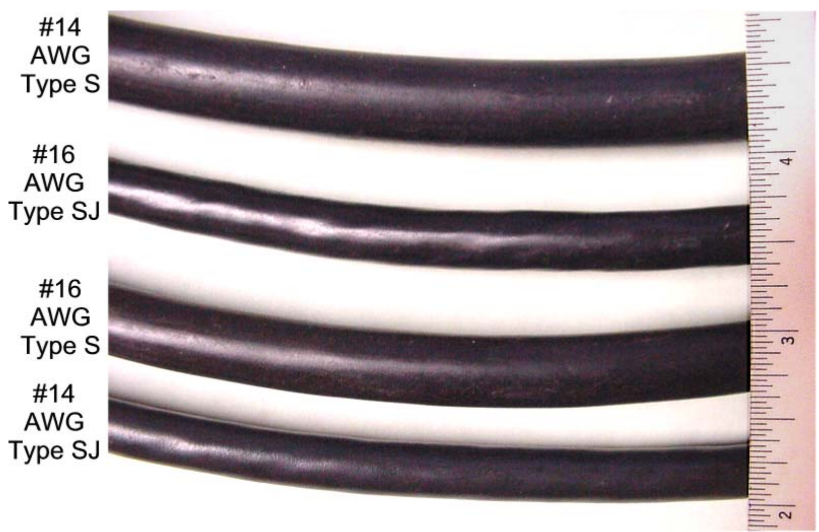
The National Electrical Code (NEC) lists a maximum allowable amount of current that each type of cord is permitted to carry. The current limitations are based on the extent to which the currents cause the cords to heat up. (More details are on the next page.)

Length — As mentioned above, for every foot that current flows through a cord, there is a voltage loss. For a given current flow, fifty feet of cord will have twice as much voltage loss as 25 feet of the same cord.

Cord Construction

Looks can be deceiving! You can't tell how much current a cord can handle by how thick the cord is! The reason is that cords are made with different amounts of resistance to physical damage.

Two cords of noticeably different thickness may have exactly the same copper wire (and therefore current capacity) inside them. Notice in the photo of examples at right that one of the #16 AWG cords is thicker than the #14 AWG cord below it. See "Cord Marking" below for more details.



Cord Marking

Extension cords larger than lamp cord size are marked continuously along their length with several items of information. The most important marking item is the one that tells the size of the wires in the cord. This marking usually appears in a form such as "14/3," which indicates a three-conductor #14 AWG cord.

The marking item that usually follows the wire gauge tells us the type of cord, meaning the physical construction. The two types of construction likely to be found are "S" (hard service) and "SJ" (the J is for "junior," a lighter duty, less-rugged version of the type S cord. (Both types are shown in the photo.)

Additional letters may follow the S or SJ. The additional letters indicate other performance characteristics. Here are some:

Letter	**What it indicates**
T	Thermoplastic insulation, instead of a rubber-type material.
E	Thermoplastic elastomer insulation (more rubber-like than thermoplastic)
O	Oil resistant.
W	Moisture and sunlight resistant.

Multiple letters are often found, such as SJT or SJTOW or SEOW. Other markings include maximum voltage with which the cord may be used and a safety certification file number.

NEC Rules

The National Electrical Code contains some rules for using extension cords. Some of the rules state that extension cords are not permitted to be used:

- As a substitute for the fixed wiring of a structure;
- Where run through holes in walls, structural ceilings, suspended ceilings, dropped ceilings, or floors;
- Where run through doorways, windows, or similar openings;
- Where concealed behind building walls, structural ceilings, suspended ceilings, dropped ceilings, or floors.

The NEC sets limits on the amount of current that cords are permitted to carry. This is for safety, to prevent overheating the cord. The limits for common cords are given in the chart below:

Maximum amps for extension cords

Copper wire size (AWG)	Single-phase 2-wire and 3-wire cords	Three-phase cords (motors and similar loads)
16	13 amps	10 amps
14	18 amps	15 amps
12	25 amps	20 amps
10	30 amps	25 amps

The Bottom Line

Selecting an extension cord is a two-step process:

1. Based on the <u>amps needed by your equipment</u> and the <u>length of cord needed</u>, use the voltage drop chart on the next page to find what AWG size wires are needed in the cord. Pick a cord size that delivers a voltage drop of not more than 5% for the amps needed;
2. Determine what cord construction you need (hard service, water resistant, etc.).

To avoid overheating the cord, never exceed the maximum amps permitted in the chart above.

Approximate voltage drop for various extension cord gauges, lengths, and amps
(% drop from 120V in parentheses)

Cord Length, feet	Current flowing through cord			
	10A	15A	20A	30A
	Cord Size = #16 gauge wire			
10	1.0 V (0.8%)			
20	2.0 V (1.7%)			
30	2.9 V (2.4%)			
40	3.9 V (3.3%)			
50	4.9 V (4.1%)			
100	9.8 V (8.2%)			
	Cord Size = #14 gauge wire			
10	0.6 V (0.5%)	0.9 V (0.8%)		
20	1.2 V (1.0%)	1.8 V (1.5%)		
30	1.8 V (1.5%)	2.7 V (2.3%)		
40	2.4 V (2.0%)	3.6 V (3.0%)		
50	3.0 V (2.5%)	4.6 V (3.8%)		
100	6.1 V (5.1%)	9.1 V (7.6%)		
	Cord Size = #12 gauge wire			
10	0.4 V (0.3%)	0.6 V (0.5%)	0.8 V (1.7%)	
20	0.8 V (0.7%)	1.1 V (0.9%)	1.5 V (1.3%)	
30	1.1 V (0.9%)	1.7 V (1.4%)	2.3 V (1.9%)	
40	1.5 V (1.3%)	2.3 V (1.9%)	3.1 V (2.6%)	
50	1.9 V (1.6%)	2.9 V (2.4%)	3.8 V (3.2%)	
100	3.8 V (3.2%)	5.7 V (4.8%)	7.7 V (6.4%)	
	Cord Size = #10 gauge wire			
10	0.2 V (0.2%)	0.4 V (0.3%)	0.5 V (0.4%)	0.7 V (0.6%)
20	0.5 V (0.4%)	0.7 V (0.6%)	1.0 V (0.8%)	1.4 V (1.2%)
30	0.7 V (0.6%)	1.1 V (0.9%)	1.4 V (1.2%)	2.2 V (1.8%)
40	1.0 V (0.8%)	1.4 V (1.2%)	1.9 V (1.6%)	2.9 V (2.4%)
50	1.2 V (1.0%)	1.8 V (1.5%)	2.4 V (2.0%)	3.6 V (3.0%)
100	2.4 V (2.0%)	3.6 V (3.0%)	4.8 V (4.0%)	7.2 V (6.0%)

Note 1 Numbers are rounded to the nearest 0.1V and 0.1%.
Note 2 Voltage drops shown are the same for any single-phase supply voltage. Voltage drop depends only on amps.
Note 3 Values are approximate, as they are affected by factors such as temperature.
Note 4 For a given cord size and amps, voltage drop is uniform over a length of cord, so for example, a 40 ft cord has twice the voltage drop as a 20 ft cord. That means the numbers in the voltage drop columns can be added together. For example, the voltage drop for a 70 ft cord can be found by adding together the voltage drops for a 30 ft cord and a 40 ft cord.