Maintenance Positions Study Guide

This document is intended to provide information about some of the knowledge necessary to perform duties as an employee in the Maintenance departments at Community College of Allegheny County and may be used to prepare for the pre-employment assessment conducted during the search process for a vacancy. The information provided in this guide is not intended to be a comprehensive document covering all areas of the assessment. This guide may not be used or referenced during the actual assessment.

Version 1.0

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A. Preventative Maintenance – Lawn Equipment

1) Mowers
1-2-3 Maintenance
At the start of the season, usually spring, there are three main areas to focus on when it comes to lawn mower maintenance:
   a) **Change the oil:** Even if you don't think it needs it, do it! The oil should be changed at the beginning of every season. Over the course of the cutting season, dirt and other impurities will collect in the oil and those things will ruin an engine. Check the mower's owner's manual for the proper procedure.
   b) **Change the spark plug:** That little space at the end of the plug where the metal end bends at a 90 degree angle is called the gap. Many manufacturers are now packaging new plugs with the gap pre-set, so it's as simple as removing the old and installing the new. However, it's still a good idea to double-check the gap with an inexpensive spark plug gap tool just in case. Many people like to change the plug every year so you're starting every cutting season with a new spark plug.
   c) **Clean the air filter:** If the filter in your mower is an accordion-style paper type, simply remove the filter cover and blow out all the debris with a high-pressure air hose. If the filter is made from foam, wash it in a water and detergent solution, let it dry, and apply a few drops of oil to it. In some rare cases, you may need to replace the filter, but most of the time, a simple cleaning will do.

2) Blades
   a) It takes a little extra effort to remove the blade and sharpen or replace the blade. Every year, though, this should be done prior to the first cutting. You need to have a sharp blade when cutting grass, otherwise it doesn't cut the grass but, tears it instead, which can lead to a diseased lawn. Before removing the blade, be sure to detach the spark plug wire to prevent the mower from accidently starting. Then tilt the mower up and use a wrench to loosen the bolt that holds the blade on by turning it counter clockwise.
   b) Sharpening a blade can be done with a metal file, sharpening stone, or a motorized grinder. Regardless of the method used, follow the existing beveled edge on the blade by passing the file over the blade in the same direction each time. An even easier way to sharpen the blade is to use a small grinding attachment for your cordless drill. Just place the blade in a bench vice and you can hone the edge with no trouble.

3) Push Mowers
   a) For a small lawn, a simple push mower is perfect. While some workers use push mowers to take care of large lawns, it takes several hours of work and defeats the whole purpose of making the chore easier. A larger cutting deck is a good feature. Many small mowers start at around 19", but 21" is better. Also, think about how easy it is to crank and the type of bagging attachment (a rear bagger is easier to maneuver).
   b) Battery powered cordless models are becoming more and more popular. Not only are they quieter and more environmentally friendly than gas powered models, but cordless electric mowers greatly reduce the maintenance needed, since they don't need oil changes, spark plugs, or air filters.

4) Riding Mowers

For a large lawn, riding mowers are the machine of preference. Professional services use ZTR (Zero Turn Radius) mowers, which can turn on a dime. The biggest drawback for many homeowners is trying to operate the ZTR's with the two separate directional levers. The cutting decks for riding mowers start at 42". While most workers don't need one that's too big, a 48"-50" model is ideal.

Cutting Tips

Here are a few quick tips that will keep your lawn looking great:

a) Don't cut wet grass: Aside from having a tendency to clog the machine and leave clumps of wet grass all over the yard, wet grass won't cut easily. It tears, just as it does with a dull blade.
b) Set the cutting height to at least 1½": Taller grass will hold moisture better and will also allow the root system to "grab hold" of the soil better, which means a healthier lawn. Never cut more than 1/3 of the existing height. Bluegrass mixed turf should be mowed to a height of 2 ½ " to 3"
c) Don't mow in the same direction every time you cut: For example, one week mow north to south. The next week, mow east to west. This prevents ruts from forming in the yard and also lets the grass grow thicker.
d) Use a grass catcher for the first cut and last cut of the season: Use the mulching feature the rest of the time to reduce yard waste and add nutrients back into the yard.

5) Annual Maintenance

Lawnmowers need annual maintenance to keep running and cutting right. Blades need to be sharpened and balanced. Caked-up grass needs to be removed from underneath so it won't rust out the cutting deck. Oil needs to be changed. Things need to be lubricated. Nuts and bolts work loose and need to be tightened. Doing annual maintenance can keep your mower running years longer, rather than having to buy a new one. Here are the normal annual maintenance times:

a) Walk-behind mower annual maintenance (no repairs needed): 1 hour.
b) Riding mower annual maintenance (no repairs needed): 1-1/2 hours.
c) Zero-turn mower annual maintenance (no repairs needed): 2 hours.

6) Putting Your Mower Up For The Winter

a) The last time you cut grass put just enough gas in the mower to finish cutting. When you're done, run the engine till it runs out of gas. Run ALL the gas out of it. If there is too much gas in the tank to do that, either drain it out, or put fuel stabilizer in and run the engine for a few minutes to get the stabilizer down into the carburetor.
b) Change the oil. Most mower engines use straight 30 weight detergent oil. Walk-behind mowers have the oil drain plug underneath. Use a 3/8 drive ratchet with an extension. The end of the extension fits the drain plug exactly. Raise the mower on it's side, put a large pan underneath, take the oil drain plug out, set the mower back down, let the oil run out for a few minutes, then put the drain plug back in. Riding mowers usually have the oil drain on the side of the engine. Put a large pan underneath, take the drain plug out, let the oil run out for a few minutes, then put the plug back in. Fill the engine with oil. Most walk-behind mowers take up to 1 quart. Most riding mowers take up to 2 quarts. Add oil slowly, stopping frequently to check the oil level on the dipstick.

c) Other lubrication. Steering sector gear and steering linkage needs to be lubed so the mower is easy to steer. Steering arms and front wheel bearings with grease fittings need to be lubed with a grease gun. Go around the mower with an oil can and oil every moving point on the mower, every linkage point, etc, particularly the blade raise / lower arm and cutting deck linkage, blade engage arm and cutting deck linkage, etc. Most of that linkage is underneath the mower. You'll have to lay down on the driveway so you can see under there and oil those linkage points. (When lubricating bearings on a rider mower, only one pump of grease into the bearing fitting is necessary.)
d) Air filter / fuel filter / spark plug. Blow the air filter out with compressed air. If the fuel filter is a few years old put a new one on. Clean and gap the spark plug. By the way, spark plugs hardly ever give problems. If your mower won't start it's usually a carburetor/fuel problem.
e) Sharpen/balance the blade(s) so it will be ready to go next spring. On a riding mower and zero-turn mower you'll have to jack up the front of the mower and raise the cutting deck all the way up to get the blades off. Sometimes blade bolts/nuts are very tight. Use an air-powered impact wrench to remove them.
f) Clean underneath the cutting deck. While you have the blades off to sharpen them, get under the cutting deck with a scraper and scrape all the caked up grass out. Getting all that grass out from underneath the cutting deck will keep it from rusting, improve air flow, help grass blow out easier, and help the blades cut better.
g) Check belts and pulleys for excessive wear. Check the drive belt(s) and blade belt(s) for excessive wear, cuts, etc. Replace as needed. Turn the blade spindles by hand and feel for roughness and play in the bearings. Be sure to back off the blade brake so the spindle turns. Turn the pulleys by hand and feel for roughness and play in the bearings. Blade spindles and pulleys should turn smoothly with no roughness and no play (no looseness, no wobble). If you feel roughness, grinding, looseness or play in the bearings, it's time to replace them. Replace them now, before they go out completely. On some mowers you can replace just the bearings. On some mowers you have to replace the entire blade spindle assembly or the entire pulley.
h) Note: Sometimes it's easier to unhook the cutting deck from the mower, pull it out, and lean it up against the mower to sharpen blades, clean grass out, check belts, check pulleys, check blade spindles, etc.
i) Inflate tires to proper pressure. Recommended pressure is on the side of the tire. Sometimes it's difficult to see, but it's there.
j) Disconnect the battery. All you have to do is disconnect the negative battery cable. This is also a good time to clean the cables and battery terminals. After cleaning them, smear grease on them with a small brush to prevent corrosion, especially the positive terminal.
k) Hose off the entire mower. Wash all the grass and dirt off the entire mower. Hit everything, including the engine, battery area, and top of the cutting deck.
l) Do steps 1 - 4 and 10 on your weedeater and anything else with an engine that you won't be using during the winter.
m) Getting the gas out of it, or adding fuel stabilizer, is the most important thing. The gas goes stale, in some cases varnishes up the carb, and the mower won't start next spring. Then you would need to drain the old gas out, pull the carb off, take it apart, clean it, put it back on the mower, blow the fuel line out, sometimes put a new fuel filter on, and put fresh gas in for the mower to start and run right.

n) Keep the battery charged during the winter. Put a trickle-charger on it, or check the voltage once per month during the winter. If it drops below 12 volts, recharge it. Many batteries go bad during the winter because they're allowed to discharge completely.

o) Keep tires inflated during the winter. If a tire goes flat, sometimes it breaks the bead loose from the rim. You'll have to reseat the bead to inflate the tire again. Avoid that by keeping the tires inflated during the winter. Check them about once per month.

(Source: www.dannylipford.com)

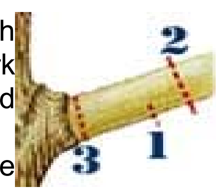
B. Groundskeeping - Pruning

1) A tree may need pruning for a variety of reasons:
   a) to remove diseased or storm-damaged branches
   b) to thin the crown to permit new growth and better air circulation
   c) to reduce the height of a tree
   d) to remove obstructing lower branches
   e) to shape a tree for design purposes

   Once the decision has been made to prune, your next decision is whether or not to tackle the job yourself. In the case of a large tree where you want to remove branches in the upper area of the crown, it may be best to hire experts. Large tree pruning, in particular, can require climbing and heavy saws or even cherry-pickers and chain saws. However, there are new tools available that can make this a manageable job.

2) <u>How to Prune</u>

   Whether the tree is large or small, the key is to prune the unwanted branch while protecting the stem or trunk wood of the tree. Tree branches grow from stems at nodes and pruning always takes place on the branch side of a stem-branch node. Branches and stems are separated by a lip of tissue called a stem collar which grows out from the stem at the base of the branch. All pruning cuts should be made on the branch side of this stem collar. This protects the stem and the other branches that might be growing from it. It also allows the tree to heal more effectively after the prune. To prevent tearing of the bark and stem wood, particularly in the case of larger branches, use the following procedure:

   a) Make a small wedge shaped cut on the underside of the branch just on the branch side of the stem collar. This will break the bark at that point and prevent a tear from running along the bark and stem tissue.
   b) Somewhat farther along the branch, starting at the top of the branch, cut all the way through the branch leaving a stub end.
   c) Finally, make a third cut parallel to and just on the branch side with in 1/2” of the of the stem collar to reduce the length of the stub as much as possible. A similar procedure is used in pruning one of two branches (or one large branch and a stem) joined together in a 'u' or 'v' crotch. This is known as a drop crotch cut. Make the first notch cut on the underside of the branch you're pruning well up from the crotch. For the second cut, cut completely through the branch from inside the crotch well up from the ridge of bark joining the two branches. Finally,

to shorten the remaining stub, make the third cut just to one side of the branch bark ridge and roughly parallel to it. *(Source: www.tree-pruning.com)*

C. Fertilizers

1) All fertilizers are labeled with three numbers that represent the primary nutrients that plants need: nitrogen, phosphorous and potassium. They are always listed as a percentage of those nutrients and always in that order. For example, a 4-1-2 fertilizer contains 4 percent, by weight, nitrogen, 1 percent phosphorous and 2 percent potassium. These can occur in different ratios and combinations, but they all represent the strength or concentration of the fertilizer. So an 8-2-4 would be twice as concentrated as a 4-1-2. This is important when comparing prices because it would take twice as much of the second fertilizer to equal the same amount of nutrient as the first.

2) What do the Three Primary Nutrients do? –
   Nitrogen is very important in plants for good foliage growth and dark green color. Phosphorous is important for rooting and also for blooming, and potassium is important for cold hardiness and plays a role in fruiting and blooming. It is possible to use a balanced fertilizer, one where the three numbers are equal or close to one another (15-15-15), throughout the growing cycle. A better plan is to look for a fertilizer brand that has at least two formulas to accommodate different stages in the plants growing cycle and/or different varieties of plants.
   For vegetables grown mostly for their leaves (salad or other greens) a fertilizer with more nitrogen than anything else (a higher first number) is best. For vegetables that flower first like peppers and tomatoes, a fertilizer with a higher proportion of phosphorus (a higher middle number) works well. Alternatively, some gardeners produce great results by using a high growth (high nitrogen) formula for the beginning of the growth cycle and then switch to a high bloom (high phosphorus) fertilizer when the plants begin to flower.

3) Micronutrients**:**
   The three primary macronutrients have been discussed, but what about the other micronutrients that plants need to stay healthy. Fortunately the better fertilizer companies have added these micronutrients to their products as well. It is a good idea to look for a brand of fertilizer that includes additives to address necessary micronutrients. The following is a list of micronutrients and their functions:
   a) Calcium (Ca)
      1) Strongly influences proper soil pH
      2) Essential to strong cell wall structure and cell division
      3) Can improve soil structure and water retention
   b) Magnesium (Mg)
      1) Plays an important role in photosynthesis and chlorophyll production
      2) A necessary component in many essential enzyme systems within plants
      3) Important in aiding the plants use of phosphorous
   c) Sulfur (S)
      1) Works with nitrogen to produce new protein for plant growth
      2) Plays an important role in the utilization of oxygen
      3) Influences the level of activity of soil microorganisms
   d) Iron (Fe)
      1) Necessary for the formation of the chlorophyll

   2) Aids in the activation of a number of biochemical processes within the plant
e) Manganese (Mn)
   1) Important to the formation of chlorophyll and the activation of the initial growth process
f) Zinc (Zn)
   1) Necessary for the production of chlorophyll
g) Copper (Cu)
   1) Important in the synthesis of certain plant growth substances
   2) Serves as an activator for several essential enzymes
h) Chlorine (Cl)
   1) May help in the regulation of osmotic pressure within the plant cell

4) Both organic and chemical fertilizers are available in dry and liquid forms. Once a decision is made concerning which type to use, the information can be applied to compare and select the most economical brands. Regardless of which brand is selected it is a good idea to have a few favorites and switch fertilizers every few months.

(Source: vegetablegardens.suite101.com)

2. Maintenance – General

A. Door hardware lubricants

1) When you insert your key into the lock and it is difficult to turn, or even to slide the key in or out of the keyhole, the lock probably needs to be lubricated. To confirm this, try using the key when the door is standing open. If it is still difficult to operate, then the problem lies in the lock.

2) There are a couple different types of lubricants that can be used in a lock, but we prefer graphite powder. Graphite powder is odorless and tends to stay in the lock rather than sticking to the key. If you use a petroleum based oil, it can make your keys oily and worse, dust tends to stick to it inside the lock and become gunky. Silicone products are also acceptable. However, whichever you choose, stick with that lubricant. Mixing lubricants is a sure way to gunk up a lock.

3) Graphite powder comes in a small squeeze tube. Simply uncap the tube, place the tip of the tube in the keyhole, tip the tube up slightly and give a couple of squeezes to blow the powder into the lock. Now insert your key repeatedly and turn the lock repeatedly to work the powder into the lock. You should also lubricate the bolt by squeezing graphite into the cracks around the bolt or latch on the edge of the door. Some lubricant manufacturers also have silicone based products that do well.

4) The lock should operate more smoothly now. If it is still difficult to operate, the problem may lie in the doorknob itself, the latch mechanism or the alignment of the door with the latch plate in the door jamb. Disassembly of the door knob and latch may help to identify the problem. If pulling or pushing on the door makes it easier to unlock, then the door's alignment is the problem. Adjustment of strike plate, on the door jamb, may help correct this problem.

(Source: www.acmehowto.com)

B. Keying

1) What is a Master Key System?
   a) A master key system is a set of locks that are keyed so that they each may have an individual key, called a pass key, yet all are opened by an additional, special key called a master key. These locks would be described as keyed different and master keyed.
   b) Within a master key system, groups of locks can be keyed alike, so that the same key operates all locks in the group, plus all locks in the group are operated by the master key. These locks would be described as keyed alike and master keyed.
   c) Under the master, groups of locks can be keyed different, keyed to a submaster, and keyed to the master. For example, you might have three buildings. Each building has six locks keyed differently and a submaster key that operates all the locks within a single building. The master key opens all

the locks in all three buildings, but the submaster from one building will not open any lock in either of the other two buildings.

d) A grand master key might be necessary if a property manager is responsible for groups of buildings, for example. Each group of buildings would be under a separate master key; each building would have a submaster key; and overall would be the grand master key that would open everything.
e) The weakness of a master key system is in the key control. If the wrong person gets a copy of the grand master key, every lock in the system may have to be changed.
f) The way a master key system is laid out determines the ability that each individual key holder may have to operate any given lock. Therefore it is best to have a clear idea of who needs to get in before you start.

2) Identify the Doors
If your master key system is going to be part of new construction, use the door numbers from the architect's hardware schedule to identify the doors. If this is an existing facility, you can assign names or numbers to the doors as you see fit. The point of this is to be able to match up a key with a door in the future so that you will be able to look at your keying schedule and identify what key(s) open which door.

(Source: www.hubpages.com)

C. Drill bits

1) Drill Accessories Safety Tips
   a) When drilling with hole saws or large capacity bits, use a drill press or clamp the material to the table. If this is not possible, beware that the drill bits can bind in the material if the drill is not held exactly level with the hole. If the drill bit binds, it may stop moving, but the drill may continue to move, taking your hand with it.
   b) Avoid burning the workpiece by drilling at slower speeds when using a hole saw or large capacity cutter.
   c) Never try to free up a jammed drill bit by stopping and starting the drill.
   d) Always unplug the drill before changing bits and accessories.
   e) Always have secure footing when drilling. Carefully brace yourself when drilling on a scaffolding or ladder.
   f) Always make sure the drill chuck is securely tightened around the spindle of the drill bit.

2) Twist Drill Bit
   a) Used in both wood and unhardened metals to make clearance holes for bolts, screws, etc., and to make holes for tapping.
   b) Bits marked HS (high speed) or HSS (high speed steel) are suitable for drilling in metals or wood,
   c) Bits made of carbon steel should be used only in wood and not in metal as they are more brittle and less flexible than HSS bits.

3) Hole Saw
   a) Cup-shaped blade with a bit in the middle, called a mandrel.
   b) Used for cutting holes in wood, plastic, plaster and light metals.
   c) Available in a range of diameters

4) Brad Point Bit
   a) Used for wood drilling only.
   b) Tip has a screw-type point leading the drill flute that prevents drill walking.
   c) Helps prevent splintering, as the brad point is the first part of the drill to emerge, allowing the user to back the drill out of the hole and finish from the other side of the material.

5) Spade Drill Bit
   a) Used in electric drills and drill presses for fast drilling of holes in wood.
   b) Bits have a forged, flat paddle with a point and cutting edges on one end.
   c) Bits are heat treated and cutting angles finish ground.
   d) Electricians use them for drilling clearance holes for wire in floor beams.

6) Countersink Bits
   a) Widen holes so flathead screws may be flush mounted below the surface for a finished appearance.
   b) The counterbore is another version that makes a straight-walled hole so there's room for a wooden plug.

7) Auger Drill Bit
   a) Most commonly used with a brace for drilling holes in wood.
   b) Length varies from 7" to 10".
   c) Dowel bits are short auger bits from 5" long.
   d) Long (ship) auger bits range from 12" to 30

8) Expansion Bit
   a) Takes the place of many larger bits.
   b) It is adjusted by moving the cutting blade in or out by a geared dial or by a lockscrew to vary the size of the hole

9) Masonry Bit
   a) Also known as a carbide-tipped bit.
   b) Used in electric drills, drill presses or hand drills for drilling holes in brick, tile, cement, marble and other soft masonry materials.
   c) Some versions have a titanium nitride-coated tip.
   d) Feature two machined in spiral threads, one for each cutting edge, to provide passageways for all dust and cuttings from the bottom of the hole.
   e) Diameters of carbide tips are the same as the full diameter of the body.

10) Tile Bit
   a) Used for drilling ceramic tile and glass.
   b) Has a ground tungsten carbide tip.
   c) Best if used with a variable speed power drill at a low speed.

11) Step Bit
   a) Has a graduated design so that various sized holes can be cut without changing bits.

b) Designed for use with power drills and has self-starting tips eliminating the need for center punching. Can be used on all materials, but especially designed for use on metals.

12) Circle Cutter
   a) Also known as a fly cutter.
   b) Has a cutting blade attached to a horizontal arm. It can cut holes up to 7” in diameter.
   c) Primarily used on a drill press

(Source:www.doityourself.com)

D. Woodworking

1) Types of Wood for Woodworking
   a) Solid wood — that is, wood cut into boards from the trunk of the tree — makes up most of the wood in a piece of furniture. The type of wood you choose determines the beauty and strength of the piece. Many varieties of wood are available and each has its own properties. The following sections introduce you to the most common types of soft- and hardwoods.
   b) Softwoods aren't weaker than hardwoods. Softwoods come from coniferous trees such as cedar, fir, and pine and tend to be somewhat yellow or reddish in appearance. Because most coniferous trees grow fast and straight, softwoods are generally less expensive than hardwoods.

2) The following is a list of common softwood varieties and their characteristics.
   a) Cedar
      1) The most common type of cedar is the western red variety. Western red cedar, as its name implies, has a reddish color to it. This type of wood is relatively soft (1 on a scale of 1 to 4), has a straight grain, and has a slightly aromatic smell. Western Red cedar is mostly used for outdoor projects such as furniture, decks, and building exteriors because it can handle moist environments without rotting. Western red cedar is moderately priced and can be found at most home centers.
   b) Fir
      1) Often referred to as Douglas Fir, this wood is very soft, has a straight, pronounced grain, and has a reddish brown tint to it. Fir is most often used for building; however, it's inexpensive and can be used for some furniture-making as well. It doesn't have the most interesting grain pattern and doesn't take stain very well, so it's best to use it only when you intend to paint the finished product. Douglas fir is pretty hard, rating 4 on a scale of 1 to 4.
      2) This wood is worth mentioning because it is very common at your local home center and it's so inexpensive you'll probably be tempted to make something with it.
   c) Pine
      1) Pine comes in several varieties, including Ponderosa, Sugar, White, and Yellow, and all of them make great furniture. In some areas of the country (especially southwest United States), pine is the wood to use. Pine is very easy to work with and, because most varieties are relatively soft, it lends itself to carving.

        2) Pine generally takes stain very well (as long as you seal the wood first), although Ponderosa pine tends to ooze sap, so be careful when using this stuff. Pine is available from most home centers, but it's often of a lesser grade than what you can find at a decent lumberyard.
    d) Redwood
        1) Like cedar, redwood is used mostly for outdoor projects because of its resistance to moisture. Redwood (California redwood) is fairly soft and has a straight grain. As its name suggests, it has a reddish tint to it. Redwood is easy to work with, is relatively soft (2 on a scale of 1 to 4), and is moderately priced. You can find redwood at your local home center.
    e) Hardwoods
        1) Most woodworkers love to work with hardwoods. The variety of colors, textures, and grain patterns makes for some beautiful and interesting-looking furniture. The downside to hardwoods is their price. Some of the more exotic species can be too expensive to use for anything more than an accent.

3) Following is a list of common hardwoods and their characteristics:
    a) Ash
        1) Ash is a white-to-pale-brown colored wood with a straight grain. It's pretty easy to work with (hardness of 4 on a scale of 1 to 5) and takes stain quite nicely, but ash is getting harder and harder to find. You won't find ash at your local home center — it's only available from larger lumberyards. Ash is a good substitute for white oak.
    b) Birch
        1) Birch comes in two varieties: yellow and white. Yellow birch is a pale yellow-to-white wood with reddish-brown heartwood, whereas white birch has a whiter color that resembles maple. Both types of birch have a hardness of 4 on a scale of 1 to 5. Birch is readily available and less expensive than many other hardwoods. You can find birch at many home centers, although the selection is better at a lumberyard.
        2) Birch is stable and easy to work with. However, it's hard to stain because it can get blotchy, so you might prefer to paint anything that you make with birch.
    c) Cherry
        1) Cherry is a very popular and all-around great wood; easy to work with, stains and finishes well with just oil, and ages beautifully. Cherry's heartwood has a reddish-brown color to it and the sapwood is almost white. Cherry has a hardness of 2 on a scale of 1 to 5. This is a very common wood for furniture-making and is available from sustainably-grown forests. You won't find cherry at your local home center, so a trip to the lumberyard is necessary if you want to use it. Because it's in demand, cherry is getting somewhat expensive compared to other domestic hardwoods, such as oak and maple.
    d) Mahogany
        1) One of the great furniture woods, mahogany (also called Honduran mahogany) has a reddish-brown-to-deep-red tint, a straight grain, medium texture, and a hardness of around 2 on a scale of 1 to 5. It takes stain very well and looks great with just a coat (or 10) of oil.
        2) The only drawback is that mahogany isn't being grown in sustainable forests. Forget going to your home center to get some — the only place to find mahogany is a decent lumberyard (and it'll cost you).

e) Maple
  1) Maple comes in two varieties: hard and soft. Both varieties are harder than many other woods; hard maple is so hard (a 5 on a scale of 1 to 5) that it's difficult to work with. Soft maple, on the other hand, is relatively easy to work with. Because of their fine, straight grain, both varieties are more stable than many other woods. They also tend to be less expensive than other hardwoods. You won't find maple at your local home center, but most lumberyards have a good selection of it.

f) Oak
  1) Oak is one of the most used woods for furniture. Available in two varieties — red and white — oak is strong (hardness of about 4 on a scale of 1 to 5) and easy to work with. White oak is preferred for furniture-making because it has a more attractive figure than red oak (white oak is also resistant to moisture and can be used on outdoor furniture).

g) Poplar
  1) Poplar is one of the less expensive hardwoods. It's also fairly soft (1 in hardness on a scale of 1 to 5), which makes it easy to work with. Poplar has a white color with some green or brown streaks in the heartwood. Because poplar is not the most beautiful wood, it's rarely used in fine furniture and if it is, it's almost always painted. Poplar can be a good choice for drawers (where it won't be seen) because it is stable and inexpensive. You can find poplar at larger home centers, but a lumberyard will have a better selection.

h) Teak
  1) Teak is becoming rarer as the days go on, but it is the staple for fine outdoor furniture. Teak is highly weather-resistant and beautiful (not to mention expensive — can you believe almost $24 a board foot?). Teak has an oily feel and a golden-brown color. It rates a 3 on a scale of 1 to 5 for hardness and is only available from larger lumberyards and specialty suppliers.

i) Walnut
  1) With a hardness of about 4 on a 1 to 5 scale, walnut is a rich brown wood that's easy to work with. Unfortunately, walnut is somewhat expensive (usually around $8 a board foot) and finding large boards for big projects is getting difficult. In spite of this, walnut is still a great wood to work with and lends itself nicely for use as accents and inlays to dress up a project. You won't find walnut at your local home center and you may need to special order it from a lumberyard if you want a large quantity.

(Source: www.dummies.com)

E. Saw Blades

1) Saws Safety Tips
  a) Always wear proper eye protection, such as safety glasses or a face shield.
  b) When selecting any type of saw, be sure to pick one that is the right size and design for the type of material being cut.
  c) The right saw handle should keep the user’s wrist in somewhat of a natural position that is horizontal to the piece being cut.
  d) Always make sure the piece being cut is free of objects such as screws and nails, that could make the saw buckle,.
  e) To start the cut properly, place your hand with the thumb in an upright position pressing against blade. Go slow at first to prevent blade from

jumping off the cut line. Then, after the blade is engaged, begin with partial cutting strokes and be sure to set the saw at the proper angle.

f) During the cut, pressure is applied only during the downstroke.
g) Be sure the stock being cut is secured firmly in place.
h) When cutting longer stock, always be sure the stock is properly supported.
i) Pull teeth can be a safety hazard. Always make sure the teeth and blades are properly sharpened, set and cleaned.
j) Always protect the teeth of any saw when the tool is not in use.
k) When using hacksaws, make sure the bade is secured with the teeth pointing forward and that the frame is aligned properly.
l) When cutting with a hacksaw, use the full length of blade in each cutting stroke.

2) Rip Saw
   a) Has large, chisel-shaped teeth, usually 5-1/2 teeth per inch, and is made to cut with the wood grain.
   b) Blade lengths measure from 24" to 28".
   c) Teeth are cross-filed to ensure that the chisel point is set square to the direction of cutting for best performance.
   d) This saw is best held at a 60º angle to the surface of the board being cut. The ripping action of the saw produces a coarse, ragged cut that makes the saw unsatisfactory for finish work.

3) Crosscut Saw
   a) Designed for cutting across wood grain and produces a smoother cut than rip saws.
   b) Has teeth shaped like knife points to crumble out wood between cuts.
   c) The most commonly used crosscut saws are 10- to 12-point for fine work and 7- or 8-point for faster cutting. 10 teeth per inch is considered general purpose
   d) Blade lengths range from 20" to 28", with 26" the most popular.
   e) Can also be used to cut plywood.
   f) Best cutting angle for this saw is about 45º.

4) Hacksaw
   a) Is a fine-toothed saw designed to cut metal or plastic. Hacksaws consist of a blade held in a steel frame with relatively high tension to hold the blade rigidly straight. High-tension models (with tension to 32,000 p.s.i.) are also available.
   b) Blades come in coarse-, medium (18 tpi), fine (24 teeth per inch and very fine-toothed (32 tpi). Regular or standard blades are used for general-purpose cutting; high-speed or bi-metal blades for cutting hard, extra-tough steel.
   c) Most models can be adjusted to hold various blade lengths. Some have both horizontal and vertical positions for blades. Others provide blade storage.
   d) A close-quarter (or utility) hacksaw holds and positions a hacksaw blade so it can be used effectively in narrow spaces and slots.
   e) Replacement blades include rod saw blades capable of cutting through most hard materials—spring and stainless steel, chain, brick, glass and tile.

5) Compass or Keyhole Saw
   a) Cuts curved or straight-sided holes.

b) Saw blades are narrow, tapered nearly to a point to fit into most spaces.
c) Blades come in three or four styles that can be changed to fit the job.
d) Some models have induction-hardened teeth for longer life without sharpening.
e) Keyhole saws are small compass saws with finer teeth that can cut metal.
f) Turret head keyhole blades can be rotated and locked in several positions for easier cutting in tight, awkward spots.

6) Coping Saw
   a) Used for cutting irregular shapes, curves and intricate decorative patterns.
   b) Name comes from saw's usefulness in coping back the joints of molding when fitting two pieces together.
   c) Saw consists of a thin blade and a C-shaped steel tension frame.
   d) The removable blade is typically 6-1/2" long.

7) Backsaw
   a) Is a thick-bladed saw with a stiff, reinforced back to provide the rigidity necessary in precision cutting.
   b) It varies in length from 10" to 30" and is found in tooth counts from seven to 14 teeth per inch.
   c) Used with miter boxes to cut miters.

8) Bow Saw
   a) Consists of a tubular steel frame and a saw blade for fast cutting of all woods.
   b) The bow saw's frame is important, since the thin blade, usually 3/4" wide, must be held under high tension for fast cutting.
   c) Advantages of this general-purpose saw are its all-around utility and light weight.
   d) Some bow saws are designed to hold hacksaw blades as well as standard bow saw blades. These multi-purpose saws can be used to cut wood, metal or plastic.

9) Dovetail Saw
   a) Similar to a backsaw, with stiff reinforced back, only smaller with finer teeth.
   b) Used for fine finish cuts, such as cutting dovetail joints in woodworking.
   c) Common saw for trimming molding and furniture repair.
   d) Can also be used to cut plastics and laminates.

10) Toolbox Saw
   a) Also called Panel Saw or Short Cut Saw.
   b) Good for ripping, crosscutting and general cutting of lumber, plywood and particleboard and plastic materials.

11) Drywall Saw
   a) Resembles a kitchen knife in design and is used to cut drywall and plasterboard in the same fashion as a keyhole saw, such as for sawing holes for electric outlets and switchplates.
   b) The saw is self-starting with a sharp point for plunge cuts.
   c) It may also have induction teeth for longer life without sharpening.

12) Plywood Saw
   a) Is specially designed for sawing plywood, veneers, laminates and moldings.
   b) The blade, which cuts on the push stroke, is curved downward at the end to allow user to start cuts in the center of a board.
   c) Not designed for cutting solid wood.
   d) Standard saw lengths are 12"-13", generally with 14 teeth per inch.

13) Pull Saw
   a) Is similar to most traditional saws except the teeth are designed to cut with a pulling motion.
   b) Pull saws cut wood faster and with less effort because of the thinner and more flexible blade.
   c) The saws feature teeth diamond-ground on three cutting edges.
   d) Because of the flexibility of the blade and the minimal set to the teeth, the saws are excellent for flush cutting.
   e) Mini pull saws that cut sharply on the pull stroke are used for precision carpentry.

14) Plastic Pipe Saw
   a) Designed to cut PVC and ABS plastic.
   b) Can also cut wood and drywall.

15) Retractable Saw
   a) Comes in a variety of designs and is engineered for the blades to either retract or fold back into a plastic or wooden handle.
   b) Also called a folding saw.
   c) Some models have combination features, such as utility knives, on end opposite saw blade.

16) Miter Box
   a) Used to help cut exact angles for wood trim and rafters.
   b) Better models provide a mechanism for a backsaw.
   c) They are made of plastic, hardwood or aluminum.
   d) Some boxes feature magnetic mount guides. The magnets grasp and hold the saw to the miter box saw guide or hold the saw blade to the plane of the saw guide.

(Source: www.doityourself.com)

F. Concrete ordering:

1) Calculations
   a) Calculate the right volume. Concrete is always ordered in cubic yards. First figure out the cubic footage, then convert to yards by dividing by 27. Here's how:
      1) multiply the length of your project times the width times the depth (4 in. = 33 ft.) and divide the total by 27.
      2) Using a sidewalk as an example: 60 ft. (long) x 4 ft. (wide) x .33 ft. (deep) = 79.2 cu. ft. ÷ 27 = 2.93 cu. yards. You can also figure your cubic yards by this example: length times width, divided by 12, times thickness, divided by 27.

3) Using the figures from above example. 60 ft (length), times 4 ft (width), divided by 12, times 4 inches (thickness), divided by 27 = 2.96 cubic yards.
4) Concrete is cheap and nothing is worse than coming up short (except rain). A good rule of thumb is to order an extra 5 percent rounded up to the next 1/4 yd. to handle spillage and uneven bases.

b) Order from the nearest supplier. Get fresh concrete mixed near the site, not mixed across town by some company with a lower price.
c) Ask for 5 percent “air entrainment” in the mix. Suppliers add a chemical that traps microscopic air bubbles to help the concrete handle the expansion and shrinkage caused by climatic changes such as freezing.
d) Get the right strength. Tell them you’re pouring an exterior sidewalk and they’ll recommend the correct “bag mix” (ratio of cement to gravel and sand). In cold climates, they’ll probably suggest at least a 3,000-lb. mix. That means concrete that’ll handle a 3,000-lb. load per square inch without failing.

2) Tips

a) The truck comes with the concrete premixed with the correct water content. But the driver may send a little concrete down the chute and ask if you’d like more water added. Unless the mix is too dry to get down the chute, forget it. The mix should be thick—not runny. Wetter concrete may be easier to place (fill the forms), but the wetter the mix, the weaker the concrete.

(Source: www.wikihow.com)

3. Maintenance – Automotive

A. Engine oil

1) Choose Your Oil
   a) Your owner's manual for your vehicle should recommend a certain grade of oil to be used under normal driving conditions as well as the number of miles that you can drive your vehicle before changing your oil (maximum drain interval). However, if you drive under severe conditions such as extreme temperatures, frequent short trips, stop and go traffic or towing and hauling, the extra strain on your engine will necessitate more frequent changes. The average driver generally doesn't realize it but the vast majority of their driving falls into this category, which is why most mechanics will refer to and change oil by the shorter drain interval recommended by the manufacturer for use in "severe" driving conditions.
   b) As a general rule of thumb, change your motor oil and oil filter every 3,000 miles or every 3 months, whichever comes first. This strategy will provide superior engine protection and long engine life. (Be certain to check your owner's manual for special conditions and do not exceed warranty recommendations.)

2) Prepare Your Vehicle
   a) Always be certain to consult your owner's manual for specific safety precautions before climbing under your vehicle.
   b) Never use a bumper jack to hold your vehicle up - it is simply too unstable. Portable wheel ramps are ideal and much safer. Wheel ramps will tilt the car just enough to allow you to slide underneath. After making sure that you are on level ground, drive your vehicle up onto the wheel ramps so that the front tires are elevated. Set your emergency brake and brace both rear wheels with wooden blocks to prevent the vehicle from rolling. Put your vehicle in first gear if you have a manual transmission and in Park if you have an automatic transmission. Cold oil will not drain properly so idle your engine for about 3-10 minutes to bring it to normal operating temperature (never start your engine without oil). Then switch off the engine and raise the hood to locate and loosen the oil sump cap to avoid creating a vacuum. This will allow the oil to drain from the bottom more freely.

3) Drain the Old Oil
   a) Locate the oil drain plug on the underside of your vehicle. It should be located at the bottom rear end of the engine sump or oil pan. Be sure not to loosen the automatic transmission drain plug by mistake. (It is usually located a bit further back.)
   b) Place the drain pan underneath the drain plug and slightly toward the back. Using your wrench, turn the plug counterclockwise until it rotates freely. Finish removing the plug by hand. At this point, be careful of the oil since it may release rapidly and is likely to be rather hot. Try not to drop the plug into the pan, but don't worry if you do!

4) Remove the Oil Filter
   a) Next, loosen the oil filter - which may be warm - by turning it counterclockwise with a filter wrench. Complete the removal by hand, taking care not to touch the hot exhaust manifold. The oil filter may be filled with oil and feel slightly heavy, so carefully ease it down and away from the engine and tip its contents into the drain pan.

5) Replace the Oil Filter
   a) Take your rag and wipe in and around the filter seat on the engine. Then take a new filter and use your finger to apply a light film of oil (new or used) to the gasket (the circular edge of the filter itself). This film will act as a sealant. Now gently screw the new filter onto the threaded oil line, turning it clockwise. If it's aligned properly, the filter should thread on easily. Hand-tighten the filter approximately ½ to ¾ of a turn after the gasket makes contact with the mounting surface. Make sure the filter is mounted snugly, but be gentle, Hercules; you don't want to over-tighten.
   b) Be sure to clean the copper gasket and the oil plug. Use a paper towel or rag to clean old oil or road dirt from the area on the oil pan near the oil plug hole before re-installing the drain plug. Then align and replace the plug. Screw it in by hand, but finish tightening it with your wrench. Tighten the oil plug to the proper torque recommended in the owner's manual to prevent under- or over-tightening.

6) Add Clean Oil
   a) On the top of the engine you will find a cap that says "Oil." Unscrew the cap and proceed to fill the engine with the required quantity of oil, checking with the dipstick to assure proper fill level. Use a funnel to pour the new oil into the filler hole on top of the engine (oil spilled onto the engine or exhaust system will stink up the engine; oil spilled onto the exhaust system can even potentially be ignited). Then replace the cap and wipe off any spillage. The oil light should go out as soon as the engine is started. Run the engine for several minutes, then switch it off and check the dipstick once again to assure proper oil level. Last, but not least, check under the vehicle for leaks.

(Source: www.castrol.com)

B. Automotive Radiators

1) A vehicle radiator and cooling system needs to be clean to be cool. As time goes on, your car's radiator builds solid deposits that can clog the cooling system. A quick, inexpensive radiator flush can keep the system in shape. It's important to change your antifreeze seasonally.

2) Before you start your radiator flush, make sure you have everything you need. There's nothing worse than draining your radiator only to realize that you need to drive to the auto store for something!

3) What you'll need to perform a radiator flush:
   a) Phillips head screwdriver or wrench (whichever your radiator drain requires)
   b) Cloth rag

c) Radiator Flush solution
d) Coolant
e) Funnel
f) Used coolant receptacle

4) ***Be sure to let your engine cool completely before you loosen or remove the radiator cap. Hot coolant can be painful!**

5) Performing the Flush
   a) The first step in your radiator and cooling system flush is to drain the old coolant from the radiator.
      1) Using your owner's manual or your eyeballs, locate your radiator's drain plug. It could be anywhere along the bottom of the radiator, and will be either a screw plug, bolt plug or a petcock (simple drain valve). Be sure you have your used coolant receptacle in place under the drain before you open it up.
      2) With your coolant catcher underneath the drain, unscrew it and let the coolant empty completely. If you have a screw or bolt type radiator drain plug, remove it completely. If your radiator has a petcock, open it all the way.

***IMPORTANT: Coolant can be very dangerous to pets. It tastes sweet to them but ingesting it can be fatal. Be sure not to leave any -- even a small puddle -- where an animal could drink it.**

a) Once all of the coolant has drained from the radiator, replace the drain plug and remove the radiator cap. Add the contents of the radiator flush solution to the radiator, and then fill it to the top with water.
b) Replace and tighten the radiator cap. Now start the car and let it run until it gets to its operating temperature (the place on the temp gauge that it normally stays at).
c) Turn your heater on and move the temperature control to the hottest position. Let the car run for 10 minutes with the heater on.
d) Turn the car off and wait for the engine to cool off. If the radiator cap or metal radiator is hot to the touch, it's still too hot to open.

***IMPORTANT SAFETY REMINDER: Do not attempt to loosen or remove the radiator cap while the engine is hot. Serious injury can result! Your cooling system is hot!**

e) Once the engine has cooled down, open the drain and completely empty the contents of the radiator. Your radiator flush is almost finished!
f) Depending on the size of your coolant receptacle and cooling system, you might have to empty it into a separate container to make room for the second draining. No matter what, never pour coolant on the ground!
g) Now that you have performed a radiator and cooling system flush, all you need to do is refill the radiator with fresh coolant.
h) Replace the radiator drain plug or fully close the petcock.
i) Using a funnel to eliminate spills, fill the radiator with a 50/50 mixture of coolant and water. With the radiator filled, go ahead and fill the plastic coolant reservoir if your car has separate openings, again with a 50/50 mix.
j) Tighten all of your caps well.

k) It's a good idea to <u>check your radiator coolant level</u> in a day or so to be sure it's proper, sometimes an air bubble works its way out and you need to add a little.

(Source: www.carzunlimited.com)

C. Automotive Tire Changing

1) Whenever changing a rear tire on a vehicle, it is required that the vehicle is in Park, the parking brake is engaged and the opposite side front tire is chocked.
   a) Jack up the Car
      1) The first step is to find your car's spare tire, jack and tire iron. The spare tire is almost always located underneath the floor mat in the trunk. Unless, of course, your car doesn't have a trunk. If you own an SUV, minivan or pickup, the spare tire is often mounted on the back of the tailgate or underneath the vehicle itself.
      2) Once you have found the spare tire, remove it from the car. If you have an air pressure gauge handy, you will want to check the spare tire's pressure. If this tire is flat, too, you're in a bit of trouble. But let's just assume you have been keeping tabs on the spare tire's health, and its air pressure is perfect.
      3) The next step will involve removing the flat tire. Make sure that the car is in gear (or in "park" if the car is an automatic) and the emergency brake is set. The car should be parked on a flat piece of pavement. Do not attempt to change a flat if the car is on a slope or if it is sitting on dirt. It's also a good idea to block the tire opposite of the flat tire. Therefore, if the left front tire is flat, it would be a good idea to place a brick or other large, heavy object behind the right rear tire. Blocking the tire makes the car less likely to move when you are raising it.
      4) Use the tire iron (the L-shaped bar that fits over the wheel lugs) to loosen each wheel lug. The wheel lugs are almost certainly very tight. You'll have to use brute force. You loosen them by turning them counterclockwise, by the way.
      5) Now, at this point, you don't want to actually remove the lugs. You just want them loose. Once you have accomplished this, move the jack underneath the car. If you don't know where the proper jacking points are, look them up in the owner's manual (you keep your owner's manual in your car, right?).
      6) Maneuver the jack underneath the jack point and start to raise the jack. Most car jacks these days are a screw-type scissor jack, which means you simply turn the knob at the end of the jack using the provided metal hand crank. Raise the jack until it contacts the car's frame and continue expanding the jack.

   b) Remove the Flat and Install the Spare
      1) Raise the car with the jack until the flat tire is completely raised off the ground. Once this is done, remove the wheel lugs completely. Depending on how tight the lugs are you might be able to remove them by hand. Set the lugs aside in a secure location where they can't roll away.
      2) Position the spare tire over the wheel studs. This is the most physically challenging part of the whole process. You'll have to hold up the tire and try to line up the holes in the wheel with the protruding wheel studs located on

the brake hub. One trick that might help is to balance the tire on your foot while you move it into position.

3) After you have the spare tire hanging on the wheel studs, screw each of the wheel lugs back on. You'll want to start them by hand. Make sure you do not cross-thread them. The lugs should screw on easily. Once each of them is snug and you can't tighten them any further by hand, use the tire iron to finish the job. At this point, you don't need to get the lugs super tight. You just want them snug for now. Make sure that the wheel is fitting flush against the brake hub.
4) Once the spare tire is on, carefully lower the jack. Pull the jack away from the vehicle. The final step is to tighten down the lugs completely. The reason you tighten the lugs now is that the tire is on the ground and it won't rotate around like it would if it was still hanging in the air.
5) Wheel lugs have a specific torque rating that they are supposed to be tightened down to, but there is pretty much no way you can figure that out using a simple tire iron. The general rule here is to tighten down the lugs as much as possible.
6) That's it. Put the flat tire in the space where the spare tire was and put the jack and tire iron back in the car. Most compact spare tires are smaller than regular tires , so it is possible that the flat tire won't fit in the spare tire well. Also, compact spares have a limited top speed. The tire's top speed will be written on its sidewall. If your vehicle has a full-size spare, you won't encounter these problems. With the spare installed, you should be able to reach your house or the nearest service station.

(source: www.edmunds.com)

4. Building Construction

A. Paint Brushes

1) Painting Tools Overview
   a) Although it might seem that you could use any paint brush to paint with, the brush you choose can be as important as the project itself. It doesn't make much sense to buy a top quality paint, and then apply it with a really cheap paint brush or roller. The quality of the results you achieve will be much better with a top quality paint brush. A great paint brush will hold more paint, give you more control, provide a smoother finish with fewer brush strokes and will save you time. As with anything, you get what you pay for when it comes to paint brushes. The main differences in paint brushes will be the bristle types, the taper, bristle flagging or splitting, bristle density, the ferrule and balance.

2) Bristle types
   a) There are many different types of bristles. Hog hair (or china bristle), polyester, nylon and blends. China bristle is actually hog hair. It is the best when using oil-based paint because the hog hair is stiff enough for control but soft and naturally splits at the ends for a very smooth application. Hog hair cannot be used for water-based paints however because the bristles absorb water. Polyester bristles are generally stiff. These bristles provide good control but often are too stiff for a smooth application. Nylon bristles are very soft, which make for very smooth application but are too flimsy for control. The best synthetic brushes contain a blend of polyester and nylon bristles. The polyester provide the stiffness for control while the nylon bristles provide the softness for a very smooth application. Varying quality of the filaments will also affect how well the paint flows off the bristle (called the "release").

3) Taper
   a) A good brush will taper so that the brush is actually thicker at the bottom and narrower at the top. This shape gives the brush more stiffness and control. A cheap brush will generally have bristles of all the same length. A good quality brush will have a finer tapered edge and longer bristles than the cheaper kinds.

4) Bristle flagging
   a) Flagging, or split ends, is what you see at the tips of the bristles. Flagging is when the bristles are scored or split at the end to provide finer and smoother application. Great paint brushes have flagged or split bristles whereas a cheap paint brush will not.

5) Bristle density
   a) The more bristles a paint brush has the better (too a point). Paint is held in the space between the bristles, so more bristles will hold more paint. This allows the paint to flow from the brush, giving you more control, smoother application and longer time for holding your line. You'll achieve a straighter and cleaner edge and spend less time filling your brush and more time painting. A cheaper paint brush won't hold much paint and therefore is more or less smearing the paint rather than flowing the paint onto the surface.

6) Ferrule
   a) The ferrule is the area of the brush that holds the bristles against the handle. Ferrules are commonly metal and are either square or rounded. Good paint brushes will have either a stainless steel or other rust-proof ferrule whereas a cheap brush will use a lower quality metal that is more subject to rusting. The shape of the ferrule will have an impact on the shape of the bristles. It isn't necessarily important whether it is square or rounded, and often is just a matter of personal preference.

7) Balance
   a) Most handles are made of rubber or wood. What you want in paint brushes is a balanced brush that feels comfortable in your hand and is easy to control.

8) The Right Size
   a) Your surface will determine what type of brush you use. If you have a wide surface you will want to use one of the larger 3-4 inch brushes. If you need to trim around paneled doors you will want a smaller 1½-2" brush. The most popular brush size is a 2-inch angled sash brush because it is comfortable to use and hold and can be used to trim around tight areas.

9) Paint rollers
   a) The paint roller is your best friend when it comes to painting. Rollers help you cover a very large surface area in a relatively short time. A good roller sleeve will hold a large amount of paint and release it onto the wall with minimal splattering and minimal lint. Nine inch is the most popular roller width. 3/8-inch is the most common nap length, but 5/16-inch and 1/2-inch are also commonly used. The best nap length will depend on your wall smoothness and the sheen of the paint you are using. 1/4-inch or 3/16-inch is the best nap for semi-gloss paint on a smooth surface, 3/8-inch or 5/16-inch is most common for smooth walls and matte or eggshell paint, 1/2-inch nap would be used for medium surfaces and 3/4-inch or longer would be used for rough surfaces such as concrete block.

10) Roller Handles and Trays
   a) The right paint roller handle is very important. Most people think they can just use the cheapest roller handle made with thinner gauge steel. The thinner gauge causes two problems: first, the pressure is only distributed across the roller sleeve on a couple inches closest to the handle. A good quality roller handle will distribute the pressure evenly across the whole nine-inch roller cover, so you are painting with 2 to 3 times more surface area with a good roller handle than a cheap roller handle. Second, the thin gauge doesn't provide enough tension to adequately keep the roller sleeve on the handle, so the sleeve will spin itself off the cage while you paint and you'll find yourself every few minutes trying to put it back on - this is very annoying and time consuming. A good roller handle has special locks that keep the roller cover firmly in place on the handle.
   b) A roller tray will also be necessary. You'll want to choose a tray that holds a good amount of paint and can be used with disposable liners.

11) Painting Tapes
   a) Blue painting tape is used to mask any area you don't want covered with paint. Use it to edge along the ceiling or wall prior to painting, around door and window trim and on any hardware or fixtures you don't want painting. Taking a little extra

time preparing the area before painting can ensure great results. There are two main types of blue painting tape: crepe paper and rice paper. Crepe paper tape is less expensive, but is thicker and not as smooth. Riced paper tapes are thinner and much smoother. They give the most crisp lines but are more expensive.

12) Drop cloths
   a) A drop cloth is used to protect floors and furniture from paint drips, splatters and spills. Heavy Duty Canvas is best for walking on or anywhere paint can spill. Plastic sheeting is best for covering furniture or anything else against splatters.

(Source: www.myperfectcolor.com)

13) Preparing the Brush
   a) Before painting, dip the brush into water if it will be used with latex paint or into mineral spirits if it will be used with oil paint. Dab it dry with a clean rag. This step will help keep the paint from crusting under the ferrule. If paint should dry against or behind the ferrule, the brush will be useless for painting because the bristles will be clumped — like a club — and the reservoirs to hold paint between the bristles will be destroyed.

14) Position the Brush
   a) Holding a paintbrush correctly not only reduces hand fatigue but helps to control the brush stroke and dispenses the paint smoothly. It also extends the life of the bristles.
   b) Painters with large hands often hold all their brushes like a pencil with the ferrule between the thumb and forefinger. Those with small hands often find they can do this only with their small brushes. Large three- to four-inch wide brushes are often held with all fingers on the ferrule and the crook of the thumb around the handle and the tip of thumb on the underside of the ferrule.
   c) The paintbrush should feel balanced. Hold it at a 45º angle to the surface. By holding it with your hand toward the base of the handle you improve control and prevent spatter. It will also help to relieve repetitive injury to your wrist.
   d) If the handle feels uncomfortable, experiment by covering it with layers of duct tape or spongy pipe insulation.

15) Using the Brush
   a) Don’t waste time lapping the dipped brush against the paint can rim to remove excess paint. Instead pour a few inches of paint from the original container into a clean paint can and dip the brush into the paint — dip one-third to one-half the length of the bristles into the paint. Raise it out and tap both sides of the brush against the inside of the can. Rather then having paint running off of the brush into the can rim and down the sides of the can, it flows back into the painting can. Tapping the brush also forces paint between the bristles where it is stored until the brush touches the painting surface.
   b) In a small area no more than two by three feet, begin painting in a back and forth method, from one side of the brush to the other. Force the brush against the surface just hard enough to slightly flex the bristles. Tip off, or feather the edges of the painted area. This is done by brushing out on the final stroke with the tips of the bristles and lightly pulling the brush off the surface. By feathering off on the stroke there will not be paint build up on the next stroke. Paint from the dry area

back to the previous wet stroke (area just feathered) to further avoid lap marks caused by paint build-up.

c) Never paint with the side of the brush because it splays the bristles and makes it difficult to maintain a clean edge.

16) Cleaning Brushes

a) Start cleaning the brush by swiping it back and forth across some newspaper.

b) For latex paint: Rinse the brush under running tepid to warm water making sure to have the water running down the handle, through the bristles. Holding the brush incorrectly with the water running from the bristles toward the handle traps any paint debris in the ferrule causing the bristles to separate. Use a wire brush or brush comb to remove any dried bits of paint. Rub a drop or two of dish soap into the bristles and rinse under running water.

c) If the latex paint is extremely tacky and difficult to remove, dip the brush into a solution of a quarter-cup of fabric softener to a half-gallon of warm water. Divide the mixture into two containers. Swish the brush around for a minute in the first container. The fabric softener is a wetting agent, which reduces the surface tension of the water, helping the water to dissolve the paint. Rinse the brush in the second container.

d) For oil paint: Select several containers with lids that are big enough to hold the dirty brush suspended in the container filled halfway with mineral spirits. Use the hole in the paint handle to tie the paintbrush to a paint stick or ruler laid across the container of solvent. Soaking the brush for five to ten minutes softens the paint and makes it easier to clean. Wearing plastic gloves, use a wire brush or brush comb to remove any dry paint particles Move to the next container of solvent and flex the bristles so the solvent reaches into the ferrule. When the solvent turns cloudy, move to the last container of solvent as a final rinse.

e) Be sure to mark all the solvent containers as “Poison Mineral Spirits.” The paint residue will settle to the bottom and the solvent can be poured off and used over and over. Keep the lids on tightly and store away from heat or flames.

f) Wipe the clean brushes on newspaper to remove excess water or solvent. Then spin them by hand or with a mechanical brush spinner. Do this over an empty bucket or trashcan to collect the spray.

g) Wrap the dry brushes back in their original cardboard sleeves or make a sleeve out of the paper from a double-strength grocery sack. Secure the paper with tape. Label the sleeve with the size of the brush and if it is for oil or latex. Store the brushes by hanging them by the hole drilled in their handles.

h) For a short break in painting, as long as overnight, don’t bother cleaning the brush; simply put the entire brush into a plastic bag, seal it, and put it in the refrigerator. Some do-it-yourselfers put their brushes in the freezer but this is a bad idea because the freeze-thaw cycle destroys the paint on the brush — in effect — and gums up the first few strokes. If the brush has a wooden handle it can crack, and if it has nylon bristles they will become brittle and break.

i) The worst thing you can do with a dirty paintbrush — short of tossing it into the trash — is to stand it in a container of water or mineral spirits to prevent it from drying out. Standing a brush on its bristles will distort the bristles — think of a bad hair day or a cowlick — and the brush will not be usable for painting a clean edge.

j) Finally, don’t think cleaning the brush is something that occurs only at the end of painting. If the brush should start to feel stiff and the bristles seem to be saturated, gummy, or unresponsive, stop and clean the brush. Professional painters will often clean their brushes every two hours to make sure they leave a smooth, not grainy, surface behind.

k) The well-maintained brush will lay down a thick film of paint, improving the hiding power of the paint. And because a good brush means no thick and thin spots in coverage, the painted surface should wear uniformly. With the absence of brush marks, the sheen will be uniform and the surface will not collect as much grease and grime.

(Source: www.nwrenovation.com)

B. Framing/Drywall

1) Plan Your Project
   a) Measuring: Using a tape measure, determine the dimensions of the existing space as well as the lengths of your new walls. It is a good idea to plot those dimensions on grid paper (1square=1foot) so that you have a top view of the project. Mark the wall dimensions on your drawing.
   b) Stud Spacing: Space the studs 12”, 16” or 24” on center. Note allowable wall height table below.
   c) Number of Studs: Based on spacing requirements, divide the wall length by 1 (12” o.c.), 1.3 (16” o.c.) or 2 (24” o.c.) to figure the number of studs needed. Add one more stud for each corner.
   d) Number of Track Sections: Multiply the total lineal feet of wall by 2 to figure the amount of track needed for floor and ceiling runners. Track is sold in 10’ lengths and may need to be cut per wall.

2) Tools
   a) Reversible Drill or Screw gun for installing or removing fasteners, and should have clutch to stop over penetration of fastener.
   b) Tin Snips – for trimming studs/track.
   c) Plumb Line – for aligning floor track with ceiling track.
   d) Measuring Tape – for measuring lengths and distances
   e) Framing Square – for square-cutting studs and track
   f) Level – for checking vertical/horizontal alignment
   g) C-Clamps or Open-Frame Locking Pliers – for holding unattached studs/track securely when fastening with screwgun.

3) Safety Warning
   a) Eye protection is required to safeguard against metal pieces and particles produced while cutting or screwing metal components.
   b) Safety goggles or glasses are recommended.
   c) Leather-palm Gloves are recommended to protect against sharp edges or burrs.
4) Drywall Tools
   a) Square
   b) Utility Knife or Drywall Saw
   c) Rasp
   d) Joint Compound
   e) Paper Joint Tape
   f) Joint Knives
   g) Top Runner (Track)

h) Metal Wall Stud
i) Plastic Grommet
j) Bottom Runner (Track)

5) Instructions
   a) Cut studs/runners to required lengths as you install using aviator snips or circular saw with abrasive, metal-cutting blade.
   b) Attach ceiling runner. Use drywall screws to attach to joists. For parallel joists, bridge two joists with C-runners spaced 24" o.c. or less and install ceiling runner across bridges. Use expandable fasteners in the field of an existing ceiling. Space fasteners 12"-16" on center (2" from ends of runner).
   c) Plum to position floor runner directly below ceiling runner.
   d) Attach floor runner. Use powder-actuated fasteners for concrete floor. Use drywall screws for wood subfloor. Same fastener spacing as ceiling runner. Then mark stud locations 16" or 24" o.c. top and bottom starting from the same end.
   e) Insert stud at slight angle into runners–then twist into place. Be sure all stud legs are pointed the same way for easier drywall attachment and punchouts are oriented the same way for easy plumbing or electrical installation.
   f) Screw-attach stud to ceiling runner and floor runner with 7/16" pan or wafer-head screws. Hold stud flange to runner for easier screw attachment. Attachment of drywall will hold studs in alignment.
   g) Cut tabs approximately 4" long for attaching door header and stud bracing. Tabs may be bent either up or down.
   h) Attach C-Runner bracing across studs to support cabinet attachment. C-Runner must be notched to fit between studs.
   i) Insert grommets or pieces of pipe insulation into pre-punched holes whenever you pass through wiring and/or plumbing. Your framing is now complete and ready for installing the drywall.

LIMITATIONS: 25-gauge Steel Studs are designed for use in nonload-bearing construction only. Check local building codes before beginning construction.

6) Tips
   a) The flange on a steel stud is flexible and may deflect when you're trying to pierce it with a drywall screw, especially when two panel edges meet on a single stud. To prevent this, secure the first panel to the open side of the stud (the one that's opposite the web)—to give it rigidity—and then hang the second panel. Grip the back of the stud flange near the screw connection point with your fingers (to give it support) and then drive the screw.
   b) Levels with one magnetic side are helpful when working with steel studs.
   c) Some people find it well worth the little extra money to use 20 gauge studs rather than the usual 25 gauge ones. The walls feel more solid and the cost difference typically isn't all that much.
   d) Use common sense when doing any type of work. If you are extremely tired, or rushing, you may hurt yourself.
   e) Self-tapping screws make joining pieces much easier.
   f) Don't try nailing trim into steel studs. It will not hold. Instead, use specially designed trim screws for the job.
   g) Cut steel is sharp - wear gloves.

h) Wear eye protection when cutting steel and when driving screws. It's not unheard of for a screw to jump off the power screwdriver and shoot out at you. Once it happens once, you'll appreciate your safety glasses.

7) Drywall
   a) Drywall typically comes in 4'x8' sheets and is normally installed horizontally but can be installed vertically if desired. Larger 4'x12' sheets are available however they are hard to work with unless you are a professional with a few extra hands. These larger sheets tend to break easily during transport to the job site but are great because the larger sheets mean fewer joints to tape.
   b) Thicknesses range from 1/4" - 5/8" with 1/2" being the most popular. The 1/4" sheets are often used as overlays to existing drywall and are not intended to be used in new construction. Check your local building code for requirements in your area.
   c) Composition is another factor when selecting drywall as there are various moisture resistant products commonly called 'green rock' designed for installation in high moisture areas such as garages and bathrooms. Check your local building supply store before committing to purchase. Green rocking the whole house may be overkill but is great because of it's moisture resistant properties.
   d) Prepare the wall for your new drywall by removing all old drywall, nails, screws and anything else that will prevent the new drywall sheets from laying flat on the studs.
   e) Now is a good time to inspect and repair hidden damage such as loose blocking, moisture damage, termites, etc. Don't be surprised to find steel studs instead of wood. This is really a good thing since steel has many good qualities such as added strength, termite-proof, and fire retardant. The only difference is that you have to use drywall screws instead of nails, and that is better anyway.
   f) Inspect insulation that is stapled to the studs. Use Kraft tape to repair tears in the paper backing to maximize your energy efficiency.
   g) Use triple expanding foam to seal cracks and gaps on exterior walls.
   h) Be advised that drywall has a mud cavity along the length wise seams to give the mud a place to adhere without forming a mound that will be unsightly on your finished wall.
   i) Measure the wall where you would like to install drywall. Most likely you will have to cut some pieces. When cutting drywall, use a razor knife and score a line on one side of the drywall paper. Place your knee on the opposite side of the cut and quickly pull the drywall piece towards you while at the same time pushing your knee outward to snap the drywall in a clean line. Then simply use your razor knife to cut the remaining paper along the newly formed crease.
   j) Cut the pieces being very carefully, because the knife or saw that you use always somehow seems to want to go off the line. I recommend using a straight edge as a guide for the razor knife. Remember that you don't have to press any harder than required to cut one side of the paper since you will snap the drywall along your cut line.
   k) Use a hand drywall saw to make cuts along irregular openings such as arches.
   l) A good practice when installing drywall over protruding pipes is to place the drywall against the pipe and lightly tap with a flat block of wood to dimple the

back, then pull the drywall away and use a drywall circle cutter or drywall hole saw and cut a perfect hole that should be much easier to finish out than if you punch out a large hole that requires 3-4 coats of mud to finish.

m) Locate the studs with a stud finder if they are not visible. Don't trust that your studs will all be on 16" or 24" centers. A good idea is to run a length of masking tape along the floor while you have the studs exposed and mark the center line of each stud with a high visibility marker.
n) Make sure to use a spring loaded drywall screw dimpler since they are designed to automatically countersink each drywall screw to precisely the same depth before ratcheting the screw bit as a sign to quit and back off the drill.
o) Have someone help you hold the drywall on the wall, and use the drill to install the screws in at approx 8" centers on the vertical studs. Extra screws may help in some situations however they are usually overkill and will require extra mudding and sanding that will detracting on the overall finish.
p) When possible, install the screws closer to the edges that will be trimmed so that the screw heads will be covered by baseboard or door frame trim.
q) Use at least a 6" drywall knife to apply a liberal amount of mud to each seam.
r) Have your drywall tape pre-cut and lightly dampened with clean water. Don't need to soak it down too much.
s) Recommend avoiding the perforated and fiber tapes as they don't produce a flawless finish and require gobs of extra mud and sanding to get the job done right.
t) Put drywall tape over the joint you just applied the mud, then use your 6" or 8" drywall putty knife to flatten the tape by starting at one end and pulling towards you to the other end in one smooth motion.
u) DO NOT REAPPLY THE MUD THAT IS LEFT ON YOUR BLADE. It is critical to clean your blade after each swipe to ensure a professional finish. Dip it in water in between each swipe and wipe it on the mud tray edge to ensure a clean application. The putty knife will collect small dust particles that will cause streaks in your finish which is why you will want to discard the excess mud after each swipe.
v) Inspect your recently taped joint for air bubbles. Wet your blade and flatten them out with another swipe if needed.
w) Repeat for each joint until all joints are taped.
x) Don't apply any mud over freshly taped joints! Allow them to thoroughly dry for one day between coats unless you are using hot mud that will dry in an hour. A great idea is to use pink mud that dries white indicating it is ready for another coat.
y) For corner beads you may want to use a corner tool that is available for both inside and outside corners to give your job a professional finish.
z) Apply at least 2-3 more coats using a slightly wider putty knife for each application letting it dry between each coat. It will bubble if you rush it!
aa) Don't forget to apply a swipe coat over each screw. You shouldn't notice any edges after screeding the mud over a joint line or screw dimple. Make sure to hold the blade flat against the drywall and pull towards you in smooth but firm strokes. Practice on an old piece of drywall to refine your technique.
bb) Also screed some mud over any small imperfections in the drywall that may occur during installation such as missed nail/screw holes.
cc) Many thin coats of mud will give you better results but patience is required to let it dry.

dd) Use a pole sander with drywall sand paper to sand the joints after the final coat has dried. Don't get carried away and sand until you expose the paper. This step goes quickly because the mud will sand off easily.
ee) Contrary to urban legend, you don't have to sand everything such as mud over screws or nails if you created a smooth screed of mud when you put on your top coat.
ff) Drywall breaks very easily, so when you carry it, don't let the middle bow down too much.

8) <u>How to Tape and Mud Drywall</u>
   a) Know that drywall board comes in a variety of sizes, types and widths.
      1) Typically walls are covered in 1/2 or 5/8 inch thick drywall board bought in 4x8 or 4x12 foot sheets. There are also many different specialty products on the market, such as larger 4x16 sheets, specialty ceiling boards called "CV" boards that are more resistant to sagging, and there are sheets that are 54"x8 or 12' for specialty applications such as 9' ceilings.
   b) If you find you need to cover walls that are in poor shape and past the typical amount of repair, you can also get 1/4 inch drywall sheets, but they may be as or more expensive than regular thicknesses.
      1) Ceilings and walls unless as regulated by specific fire codes are usually covered in 1/2" drywall sheets. In ceilings you usually use "CV" rated or ceiling boards. In some instances you may be required to place 5/8" drywall on your ceilings or outside walls, 5/8" drywall is usually classified as "Fire-rated" drywall and stands up to fires longer than traditional 1/2" drywall does. A special lift (easy to rent) can hold these large sheets against the ceiling while you attach them.
      2) A 'drywall lift' can also be made using 2 x 4s nailed into a T-shape that is placed under the dry wall to hold it against the ceiling as you place a few screws into the panel to secure it. However, if you are installing drywall on your own or don't think you have the upper body strength to manipulate the drywall, a lift is well worth considering renting.33
   c) Drywall that will be installed in wet locations is called green board or MR board meaning moisture resistant (for example, behind bathroom tile) must be the type that can withstand water. Usually these sheets are covered in green paper, not the usual gray.
      1) Drywall should not be used for tub surrounds or showers. The correct material would be cement board with an 8 mil vapor barrier behind it. The seams of the cement board need to be finished with a fiberglass mesh tape which is then covered with a "setting type" joint compound or "thin set" tile adhesive.
   d) Drywall that is to be installed in areas where fire is a concern, for example around a water heater enclosure, is required to be much thicker.
      1) In some municipalities you can double your drywall in fire risk areas, rather than buy far more expensive thicker sheets.
      2) Check your local planning department and municipal building codes for drywall rules and regulations in your area.
   e) Check that the drywall is attached to the wall studs correctly.
      1) Wall drywall should be screwed to all the studs it covers every six to eight inches. Ideally, it should be supported at each edge and every 12 inches in the middle of the panel in a wall framed 24 inches on center, giving you top to bottom 5 screws; in a more usual wall with studs on 16 inch centers, you will

have a row of screws on each edge plus two rows spaced 16 inches in from each edge.

f) Drywall screws **must** be correctly countersunk. Invest in a counter-sinker designed for drywall applications. This tool attaches to the end of your drill and perfectly countersinks every screw you place.
    1) Run the blade of your trowel over the screws to make sure none are sticking out. Remove, countersink or otherwise deal with any screws that are sticking out even a little bit. You want the screws to dimple but not tear the paper coating of the drywall.
    2) Do not use drywall nails unless you have been hanging drywall for years as a professional. The chances of a nail bending, putting your hammer through the drywall or simply an incorrect countersink on the nail head are great. Drywall screws are **far** easier to work with, but you will need a power screwdriver.
g) Drywall boards should meet at chamfered edges only and be no more than 1/8 to 1/4 inches apart.
    1) If two pieces of board do not meet at a chamfered edge you can use a utility knife to cut a rough chamfer all the way down the edge if you have a steady hand. If not, you will have to adjust the seam to accommodate the difference in thicknesses, placing the bulk of the mud on the chamfered side.
h) If your local municipality requires an inspection before mudding your drywall, schedule the inspection.
i) Begin with the tape coat
j) Buy ready-mixed mud and make your life much easier in one single step!
    1) Do **not** use Spackle. Mud is not Spackle, it has no "glue like" quality.
    2) Don't dilute or mess around with the mud mixture. You can do so, but there is no reason to in the vast majority of applications. Spackle is intended primarily to patch nail and other holes in drywall.
    3) There are several brands and grades of mud. Use the "all purpose" mud for your base (first) coat to seat or cover the tape, and light mud for the final coat. You can also use what is called brown or topping mud; it's actually beige and dries to a very pale color, and has a more plastic texture than regular mud. It dries smoother, has less of a tendency to bubble, and is intended for the final top coat.
    4) You can buy mud in square plastic boxes, or in tubs. It's cheaper in the boxes, if that is an issue. Try getting one tub and then boxes and use the tub with the mud from the boxes when it is empty. or use another clean plastic container that is easy to handle.
    5) Stir the mud a little, but not too much. Stirring ready-mixed mud can introduce air bubbles that will result in an uneven finish.
k) Using a trowel
    1) Plastic knives (trowels) intended for use on walls have a tendency to get burrs on their edges over time, so check if you are using plastic tools to see that they have smooth edges. Metal knives can rust, so make sure to clean them well at the end of your work session and dry them carefully.
    2) Place a generous amount of mud onto your knife.
    3) Press the mud into the seam between the drywall boards.
    4) You only need to press hard enough to fill the seam and leave smooth mud on the wall. The chamfered edge on a sheet of drywall tapers from about 2.5 inches to the edge, so you want to cover the entire six inches of drywall from edge of the chamfer on one sheet to the edge of the chamfer on the other.

Use a bright light held at an angle to better see the chamfer area that must be covered.

5) When using the wide blades loaded with mud the best bet is to place the loaded blade perpendicular to the wall, at a 45° angle. As you draw the mud and blade down the wall sharpen the angle until the blade and the wall are almost flat together.
6) Leave plenty of mud on the wall, at least three inches on each side.

l) Cut the paper drywall tape to the correct length, with a little extra on each end.
   1) Some people recommend soaking the tape in water first. While this may make it a little easier to work with it greatly increases the mess and awkwardness of the tape when actually mudding.
   2) Only use plastic, mesh or specialized tapes for their specific applications. They can be harder to work with and may require three, four or more coats of mud. If you are doing inside or outside corners, for example, mesh tape is not the best choice as the tape is not intended to fold. If you are careful mudding, you can use mesh tape on seams with two coats, but you may find that you spend more time getting a good final coat.

m) Press the tape into the freshly mudded wall with your hands.
   1) Be sure the center of the tape is as even as possible with the seam between the drywall boards.
   2) Clean your knife. Pay attention to the back as well as the front of your knife; when you are using the knife on the wall, if you see streaks pulled in the mud, you may have a bit of dried mud or something else on the back of your tool.
   3) Pressing as hard as practicable (you don't need to break your knife doing this, but you still want to press most of the mud out from under that tape), pull the knife along the seam removing extra mud as you go.
   4) The goal at this stage is to get mud into the tape, not finish the job.
   5) If your tape starts to buckle simply flatten it out with your hand.
   6) Be sure all parts of the seam and tape are mudded.

n) Once all the tape is covered in mud use a wide knife to smooth out and remove as much of the extra mud as possible.
   1) At this stage you are not going for perfection. It doesn't have to be super smooth. The important thing is to make sure the tape is covered in mud and correctly positioned in the seam. However, try not to have a large hump over the seam, or high edges. These will require sanding out later.

o) Leave this to dry. Overnight is best.
   1) While waiting, fill the screw holes with mud using your palette knife. Just apply some mud and then take it all away again, if you countersunk your screws properly you should have a small dot the size of a screw head of mud without seeing your screwhead. If you leave lines of mud behind while doing this all you're doing is creating more sanding for yourself later. Mud shrinks as it looses moisture, so you may have coat these 2 or 3 times, although small cracks can just be filled with paint.

9) <u>Corners</u>
   a) Corner seams require special attention. You will need to use a 45° knife while working in the corners.
   b) Fill the corner seam with mud and, once again, leave some mud on the wall.
   c) Cut the tape to the right length.
   d) Fold the tape down the middle. You will find a crease there to make this easier.
   e) Push the tape into the corner seam as neatly as possible.

1) Often the tape will "disappear" into the corner seam. Your goal is to make the nicest 90 degree angle possible, and this is controlled by the tape, so pull it out and start over.
2) Once the tape is in place in the mud, mud over it again using your 45° mud knife.
3) Carefully remove any extra mud from the corner and walls.

10) <u>Outside corners</u>
   a) Outside corners do not use tape, rather they use a metal corner strip. You can also buy plastic or fiberglass corner bead although this is difficult to work with.
   b) Cut the corner strip to the right length using tin snips. Be careful not to bend the corners out.
   c) Nail or screw the corner strip to the wall.
   d) Load plenty of mud onto the 6 inch knife.
   e) Pull the mud down the wall, one part of the blade resting on the metal and the other on the drywall.
   f) Make it as smooth as you can and leave to dry.
   g) Corners typically take two coats to cover the metal, but remember that your paint will also cover some of the metal.

11) <u>The second coat</u>
   a) Run your dry clean blade over yesterdays work, rubbing away obvious burrs and bumps.
      1) Use a larger blade, 8 to 12 inches in width.
      2) Understand that the goal of this coat is a smooth finish, not filling anything in, so take time and care.
   b) Load your blade with mud.
   c) Pull the mud over the seam a second time.
      1) Feather out the mud as smooth as possible to a width of about four to six inches on either side of the seam, using the knife horizontally rather than vertically, then go over the body of the seam vertically for a final smoothing.
   d) You are done when you can no longer see the tape.
      1) The idea of this second coat is to fill up the bevel of the drywall so if you were to take your drywall knife and place the edge on the seam at a 90 degree angle you wouldn't see any light between the joint and knife, ideally on the second coat you should have a **small** hump in the middle of your seam to allow for the shrinkage of the mud as it dries.
   e) Feather the edges again if necessary.
      1) Use quick but hard swipes of the blade to spread the mud out to the thinnest coat possible.
      f) After this coat has dried, inspect your work. Look for pits and holes in the mud that are too large to be filled with paint to a smooth surface. If you find such marks, do a third coat, or if the pits and holes are few, fill them to the surface of the rest of the dried mud.

12) <u>Sanding</u>
   a) Do not sand after the first coat; the tape is still too close to the surface and you risk breaking it.
   b) Always sand after the final coat.
   c) Sanding during intermediate coats is optional and depends on how smooth you can get the mud. For very light sands between coats of mud consider a *wet sand*.

        1) Find the smoothest surfaced sponge you can and wet it down so it is damp, not dripping.
        2) Rub the sponge over the mud. The sponge will re-wet the surface of the mud, filling in gaps.
        3) Continually clean your sponge.
        4) Be very careful not to use too much water or you could dislodge your previous work.
    d) Sand using a sanding block and fine sandpaper, at least 150 grit.
    e) You can also use a hand-held "orbital" sander so long as you keep it in constant movement.
    f) Seal the room as best you can and wear proper breathing protection.
        1) The dust created from sanding gypsum is very fine and unhealthy.
        2) Use a shop vacuum to clean up, after having attached a hose to vent outside.

13) <u>Tips</u>
    a) After the mud is dry, do not sand. Use a clean trowel and just scrape off the lumps and bumps.
    b) Keep the side of the tub clean by frequently moving the mud off the sides and corners into the middle. Thin mud will dry quickly forming chunks that will cause streaks.
    c) Do not use fiberglass tape, it's too expensive and the joints crack easily.
    d) Shine a light across the wall, it will show any imperfection.
    e) Tape vertical joints before taping horizontal joints. Horizontal tape joints will cover the ends of the vertical tape.
    f) Take your time. It will take two to five coats to get a perfect finish, depending on your experience, and each coat needs to dry fully.

14) <u>Warnings</u>
    a) Do not let dried mud fall back into the tub or bucket. Dried mud stays dry and will introduce bumps and problems into your work. If you do see lumps in your wall mud, remove them with your fingers or a trowel before the mud dries, otherwise you will have to sand them off and start over.
    b) Before it dries mud is water soluble, so remove drips and splashes promptly. On carpet it can work better to leave the mud to dry and then remove it.

(Source: www.doityourself.com)

C. Building Construction Suspended Ceilings

1) Following are tips and instructions on how to install a suspended ceiling. Spend a few minutes reading the directions thoroughly. This can help save you time and effort. Inside this document you will find information about:
    a) Planning for a Suspended Ceiling
    b) Installing Wall Angles
    c) Locating and Hanging Suspension Wires for Main Tees
    d) Installing Main Tees
    e) Installing Cross Tees and Border Cross Tees
    f) Installing Ceiling Panels

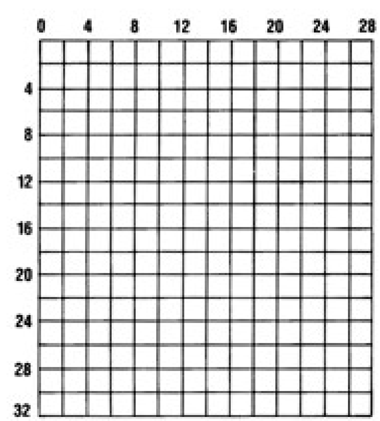


FIG. 1 - Sketch your room dimensions to scale here.

2) PLANNING FOR A SUSPENDED CEILING

   a) First, get the exact measurements of the room where the suspended ceiling will be installed. Use special care in measuring any odd-shaped alcoves, bays, etc.
   b) Draw the exact dimensions to scale on graph paper (Fig. 1), or bring the room dimensions to your local retailer and ask a salesman to assist you in estimating the materials you'll need.
   c) You can choose from either a 2x2 or a 2x4 pattern (Fig. 2). The pattern you pick will determine the material requirements for your ceiling.
   d) For the 2x4 pattern, decide whether you want to install the patterns in a standard or reverse pattern (Fig. 3). Each pattern offers a different appearance.
   e) Now that you've made these decisions, sketch the layout for the planned ceiling on graph paper. You can use the layout in Fig. 1, or purchase graph paper in a variety or stationery store. Regardless of which pattern you select, draw the main tees 4' apart. Position the tees so that the border patterns at the room edges are equal on both sides and as large as possible. Try sketching several layouts before beginning the actual installation to determine which one looks best.
   f) It is important to space the cross tees so the border panels at the ends of the room are equal and as large as possible. If you are using a 2'x4' pattern, space the 4' cross tees 2' apart. For a 2'x2' pattern, add 2' cross tees between the midpoints of the 4' cross tees (Fig. 2).
   g) If the ceiling will be recessed and built-in lighting will be installed, decide where to locate the panels of light and clearly identify them on the drawing.
   h) The drawing will help you pretty accurately estimate the total cost of the materials you'll need. Fig. 4 illustrates a basic plan for estimating costs. Add or delete materials for the job you're planning.

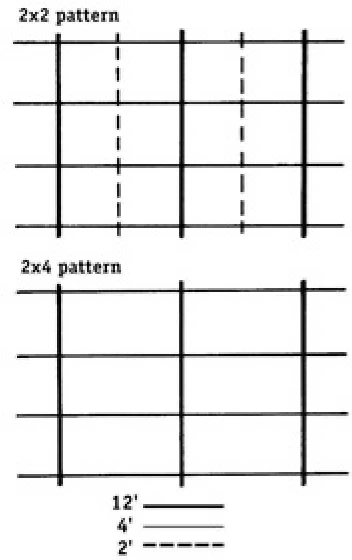


FIG. 2 - Select the grid pattern you want to use.

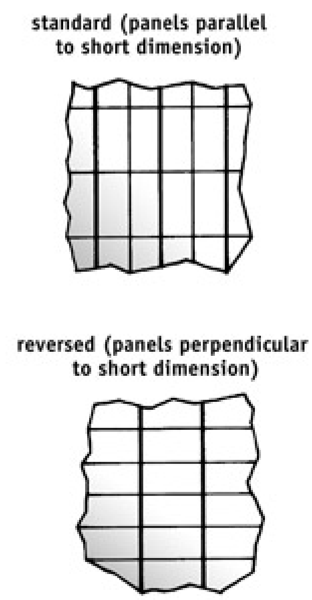


FIG. 3 - If you're using 2x4 panels, choose from either a standard or reversed pattern.

3) INSTALLING WALL ANGLES

   a) Determine the exact height at which the suspended ceiling will be installed. Allow a minimum of 3" to 4" clearance between the old ceiling and the new ceiling for installation of the ceiling panels. If clearance is a problem, you may want to use fiberglass ceiling panels, which are more flexible. Additional clearance will be required if you are using recessed lighting (Fig.5).
   b) After locating the exact position for the suspended ceiling, use a level to draw a line completely around the room indicating where the wall angle will be applied (Fig. 6). Don't assume the original ceiling is level–use a level for accuracy. Set the wall angle low enough to conceal as many pipes,

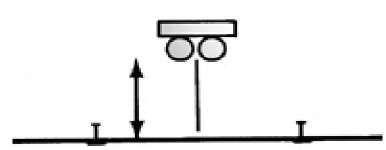


FIG. 5 - Allow a minimum of 6" space between the ceilings if you're using recessed lights.

ducts, etc., as possible.

c) Fasten the wall angles securely to the wall at all points. Nail them firmly to studs, or use screw anchors or other masonry fasteners on brick or masonry walls (Fig. 7).

d) Position the wall angle so that the bottom flange rests on the level line you have drawn on the wall. Take the time to do this right!

e) Overlap the wall angle on inside corners (A, Fig. 8), and miter the wall angle on outside corners (B, Fig. 8). Make a temporary wooden miter box if you don't have one. Cut any needed angles with metal cutting snips or a hacksaw.

4) LOCATING & HANGING SUSPENSION WIRES FOR MAIN TEES

a) If you are going to use recessed lights, install the wiring before putting the suspension wires in place (Fig. 5).

b) For recessed lighting, you can use 2x 2 or 2x 4 drop-in lighting fixtures, which are specially designed for this purpose. You can also center fluorescent light fixtures over the panels and use a luminous lay-in panel instead of a regular ceiling panel. These lay-in panels now come in several attractive designs.

c) Refer to your sketch of the room for the location of all main tees (Fig. 1). Main tees should always run at right angles to the joists in the room.

d) Locate the position of each main tee by stretching a tight line from the top edge of the wall angle on all sides of the room at each position where the main tees are to be placed (Fig. 9).

e) Now, cut the suspension wires to the proper length. The wires should be 12" longer than the distance between the old ceiling and the new guideline string you have stretched to indicate the position of each main tee.

f) Locate the first suspension wire for each main tee directly above the point where the first cross tee meets the main tee. Check your original sketch of the room to determine this location.

g) Be sure the suspension wires are securely fastened. Apply them to the ceiling with screw eyes, screw hooks, nails, or drilling (Fig. 10).

h) Attach a suspension wire every 4' along the level guideline (Fig. 11). Stretch each wire to remove any kinks and make a 90° bend where the suspension wire crosses the level line.

5) INSTALLING MAIN TEES

a) Most main tees are 12' long and have cross tee slots punched every 12" beginning 6" from each end (Fig. 12).

b) Refer to your layout sheet to determine the distance from the wall to the first cross tee. Now

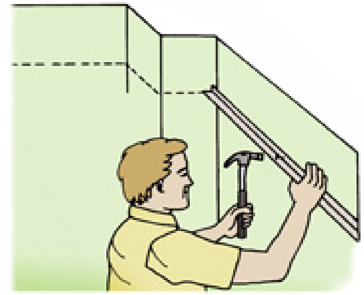


FIG. 6 - Use a level to apply the wall angle at a proper height around the room.

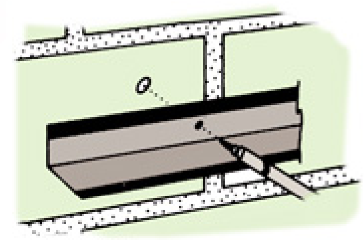


FIG. 7 - Fasten the wall angles securely to the wall at all points

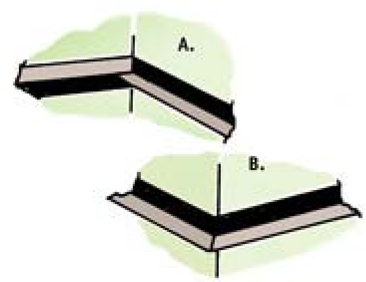


FIG. 8 - Overlap the inside corners and miter the outside corners.

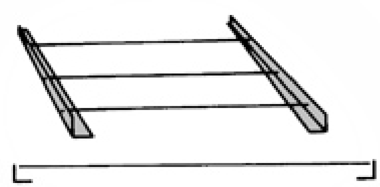


FIG. 9 - Stretch a tight line from the top edge of the wall angle on all sides of the room at each position where

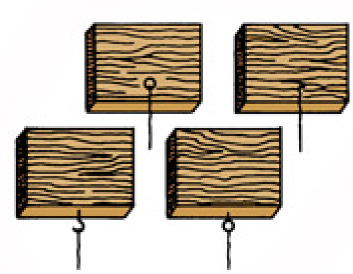


Figure 10- Be sure the suspension wires are securely fastened.

measure this distance along the top flange of the main tee and locate the slot just beyond this point.

c) From this slot, measure back the same distance, subtract 1/8" and saw the main tee at that point. The 1/8" subtraction is for the thickness of the wall angle.

d) If the wall angles are not square, position the cross tee slots accordingly.

e) When main tees are installed in rooms less than 12' across, cut the main tee to the exact measurement of the room, allowing 1/8" for the thickness of the wall angle (Fig. 13).

f) For rooms wider than 12', the main tee can be spliced (Fig. 14). Be sure to align the splice so that the suspension wires are correctly positioned. Splice carefully, or all the main tees will be thrown off.

g) Install the main tees so that they are all level with the wall angle already mounted. Use a long level for this.

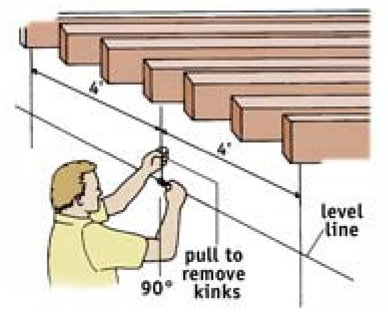


Figure 11 Add a suspension wire every 4' along the level line and bend at a 90° angle

6) INSTALLING MAIN TEES

a) Most main tees are 12' long and have cross tee slots punched every 12" beginning 6" from each end (Fig. 12).

b) Refer to your layout sheet to determine the distance from the wall to the first cross tee. Now measure this distance along the top flange of the main tee and locate the slot just beyond this point.

c) From this slot, measure back the same distance, subtract 1/8" and saw the main tee at that point. The 1/8" subtraction is for the thickness of the wall angle.

d) If the wall angles are not square, position the cross tee slots accordingly.

e) When main tees are installed in rooms less than 12' across, cut the main tee to the exact measurement of the room, allowing 1/8" for the thickness of the wall angle (Fig. 13).

f) For rooms wider than 12', the main tee can be spliced (Fig. 14). Be sure to align the splice so that the suspension wires are correctly positioned. Splice carefully, or all the main tees will be thrown off.

g) Install the main tees so that they are all level with the wall angle already mounted. Use a long level for this.

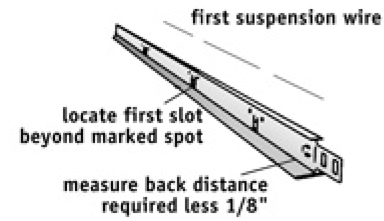


Figure 12 Main tees generally have cross tee slots every 12".

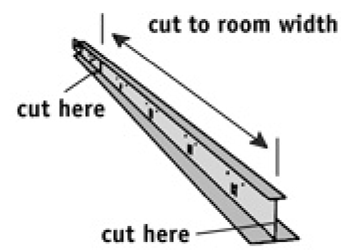


Figure 13 If the room is less than 12' across, cut the main tee to the width of the room less 1/8" for the thickness of the wall angle.

7) INSTALLING CROSS TEES & BORDER CROSS TEES

a) Install the cross tees by inserting the ends of the cross tees into the slots in the main tees (Fig. 15). Use the manufacturer's instructions for fitting the cross tees into position.

b) Determine the location of the cross tees by the pattern you selected–either 2'x2' or 2'x4' (Fig. 2).

c) Be sure the lock tab on the cross tee is on the outside of the slot (Fig. 15). This attachment is slightly different in some types of tees.

d) You can remove most cross tees by depressing the lock tab with a screwdriver.

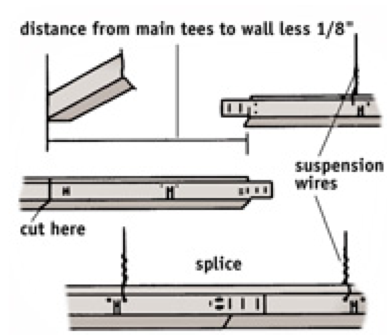


Figure 14 Main tees can be spliced for rooms wider than 12'

e) Border cross tees are installed between the wall angle and the last main tee.

f) Measure from the last tee to the wall angle, allowing 1/8" for the thickness of the wall angle. Cut the cross tees and install them by inserting the connector in the main tee and resting the cut edge on the wall angle.

8) <u>INSTALLING CEILING PANELS</u>

a) Your final main and cross tee arrangement will look similar to Fig. 16. The top part of the illustration shows an arrangement of a 2'x4' layout, while the lower half shows main and cross tees arranged for a 2'x2' layout.

b) Drop the ceiling panels into position by tilting them slightly, lifting them above the framework and letting them fall into place (Fig. 17).

c) Check your state and local codes before starting any project. Follow all safety precautions.

(Source: www.alsnetbiz.com)

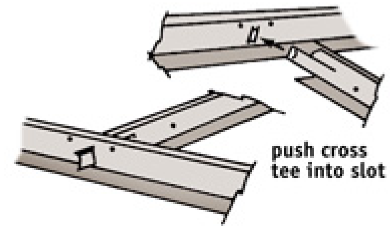


Figure 15 - Insert the cross tees into the slots in the main cross tees.

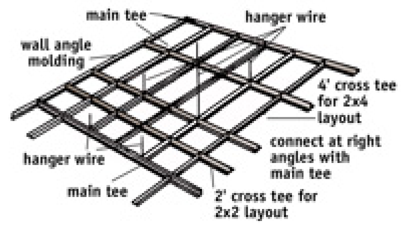


Figure 16 Your final tee arrangement will look similar to this.

Figure 17 Tilt the ceiling panels slightly and drop them into position.

Figure 4

Number	Cost per piece	Total cost
_______ 12' main beam pieces	@ _______	$ _______
_______ main beam splicers	@ _______	$ _______
_______ 4' cross tees	@ _______	$ _______
_______ 2' cross tees	@ _______	$ _______
_______ 12" wall mold	@ _______	$ _______
_______ 2x2 ceiling tiles or _______ 2x4 ceiling tiles	@ _______ @ _______	$ _______ $ _______
Total cost of ceiling		$ _______

5. HVAC

A. Belt replacement

1) The best method when replacing drive belts on a driven exhaust fan is to loosen either the fan assembly or the motor in its mount skid and push them toward each other. Then place the belt around the pulleys and force the fan assembly and/or motor away from each other and resecure in place.

2) INSTALL V-BELT in the pulley grooves by loosening the belt take-up or the adjusting screw on the motor. Do not “roll” or “snap” the belt on the pulleys; this causes too much strain on the pulleys. Be sure the belt doesn’t “bottom” in the pulley grooves.

3) ALIGN BOTH PULLEY AND SHAFTS by moving the motor on its motor mount. Hold a straight edge flush against the blower pulley, then move the motor until the belt is parallel to the straight edge.

4) A PULLEY ALIGNMENT SHORT-CUT Sight down the top of the belt from slightly above it. If the belt is straight where it leaves the pulley and does not bend, the alignment is fairly accurate.

5) CHECK BELT TENSION before proceeding further. Remember that a V-belt “rides” the inside of the pulley faces. Since the sides of the belt wedge in the pulleys, the V-belt does not have to be tight. It should be as loose as possible without slipping in the pulley grooves. Belt-Tension Adjustment Tip: Using the belt take-up or motor-adjusting screw, tighten the belt until the slack side can be depressed about 3/4″ for each foot of span between the pulleys.
6) **WARNING:** Excessive belt tension is the most frequent cause of bearing wear and noise.

(Source: www.laupats.com)

B. Filters
1) Always follow the manufacturer or Supervisor’s recommendation of when to replace filters on an air handler unit. Tips on ensuring the time ex: writing on the side of the filter with the date when last installed.

2) The U.S. Environmental Protection Agency (EPA) says that indoor air is often more polluted (typically two to five times more and occasionally 100 times more) than outdoor air. Most of the "respirable" dust and particles people breathe into their lungs is approximately three microns or smaller-a fraction of the size of a grain of sand.

3) Good indoor air quality (IAQ) depends on a number of factors, including effective filtration, which provides the primary defense for building occupants and HVAC (Heating, Ventilating and Air Conditioning) equipment against particular pollutants. Today's higher standards in filtration, coupled with rigorous attention paid to filter selection, helps to produce cleaner, purer air and reduce IAQ-related problems.

4) Filter efficiency
   a) Facility managers/engineers should work to identify the types and sizes of particular pollutants in their buildings to determine the best type of HVAC filter for their needs.

b) Selecting HVAC filters based on the needs of the facility instead of their initial costs will lead to a review of filter efficiency as a determining factor. Filtration efficiency defines how well the filter will remove contaminants.

   c) Low-efficiency filters are typically used to keep lint and dust from clogging the heating and cooling coils of an HVAC system. Medium- and high-efficiency filters are typically used to remove bacteria, pollen, soot and other small particulates.
   d) Initial and sustained efficiency are primary performance indicators for HVAC filters. Initial efficiency refers to the filter's "out-of-the-box" capability. Sustained efficiency refers to levels maintained throughout a filter's service life.
   e) Some filters have lower initial efficiency and don't achieve high efficiency until a "dirt cake" has built up on them. This happens typically after 30 days. Other filters offer high initial and sustained efficiency. This means they achieve an ideal performance level early and maintain that performance level.
   f) The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) developed two HVAC industry standards that address the efficiency issue: ASHRAE 52.1 and ASHRAE 52.2. In addition to the performance factors measured under ASHRAE 52.1 and 52.2, consider these additional variables when selecting a filter:
      1) Moisture resistance. How high humidity and moisture affect the filter;
      2) Temperature limitations. How the filter performs at application temperature; and
      3) Flammability. How the filter performs in flammability tests. Check to see if UL Class I- or Class II-rated filters are needed to conform to local building codes.

5) Filter technology
   a) There are many types of HVAC filters currently on the market, including bulk media and pre-cut pads; automatic roll filters; disposable panel filters; polyester rings, sleeves and links; pleated filters, medium- and high-efficiency bag filters; rigid cell filters; and mini-pleated filters.
   b) In most buildings, the best filter choice is a medium-efficiency pleated filter, which has a higher removal efficiency than low-efficiency filters. It also more adequately removes the particles that cause IAQ problems, unlike high-efficiency filters, which would clog.
   c) The pleated air filters used in HVAC systems are made with a wide range of materials (media), including fiberglass, polyester, cotton, paper and synthetic non-woven materials. Recent advances in non-woven technologies have allowed for a step-change improvement in both performance and value of synthetic media over standard cotton/poly blends used in HVAC filters.
   d) Unlike traditional cotton/poly media, synthetic media in more modern filters can be made of thermally bonded, continuous hydrophobic (moisture-repelling) polyolefin fibers that resist shedding and don't absorb moisture. This is important in resisting bacterial growth and keeping shed fibers from getting into HVAC coils or into the breathing air.
   e) Moreover, synthetic media can be manufactured without the use of chemical binders. This means humidity will not affect the web structure and won't cause glue to soften and thus fibers to shed.

f) Unlike cotton/poly filter media, which are made with a surface-loading structure, synthetic filter media can be made with a gradient density structure. The result is a solid mechanical foundation that maintains high efficiency over the useful life of the filter.
g) Finally, synthetic filter media have the ability to apply an electrostatic charge, which yields a higher initial efficiency and enhances the filter's capture capability. This is especially the case in the attraction of smaller diameter particles.
h) Electrostatic filtration is different than mechanical filtration, which depends on the size of the fiber, size of particles being filtered and physical structure of the media. With mechanical filtration, efficiency tends to build over time as particulates are collected.
i) With electrostatic filtration, filter fibers are charged, thus creating a force that attracts particles. This provides high-initial efficiency, and when coupled with a strong mechanical structure, high-sustained performance can be achieved.

6) HVAC filter maintenance tips
a) Proper filter maintenance is crucial to keeping HVAC ductwork clean. If dirt accumulates in the ductwork and relative humidity reaches the dew point (so that condensation occurs), then bacteria and mold may grow.
b) This is especially the case in HVAC systems that have acoustical duct liners. They're frequently used in air-handler fan housings and supply ducts to reduce sound transmission and provide thermal insulation.
c) For these reasons, it's imperative to establish appropriate filter change-out frequency. However, filters should be changed if they become wet, microbial growth on the filter media is visible, or when filters collapse or become damaged to the extent that air bypasses the media.
d) Make the job of changing filters as easy as possible. One tip filter suppliers recommend for making the job of changing filters easier is to place labels on housing units with information, including number and type of filters, date changed and pressure drop.
e) Air handlers that are located in difficult-to-access places will be more likely to suffer from poor air filter maintenance and overall decreased maintenance. Quick release and hinged access doors for maintenance, therefore, are more desirable than bolted access panels when security isn't an issue.
f) When changing the filter, make sure that the replacement filter is the correct size and compatible with your housing. Review the performance value of the filter to ensure the pressure drop across the filter won't be too great, especially as the filter loads.
g) Greater resistance will reduce air flow to the unit, creating a negative impact on the unit's heating/cooling and energy efficiency. This is another key factor to remember.
h) It's important to follow the recommendations of the filter manufacturer/supplier and HVAC system provider to determine proper procedures and frequencies for maintaining and changing filters. Also, document inspections and corrective actions should be taken into account.

(Source: www.maintenanceworld.com)

C. Pumps

1) A centrifugal pump works by the conversion of the rotational kinetic energy, typically from an electric motor or turbine, to an increased static fluid pressure. This action is described by Bernoulli's principle. The rotation of the pump impeller imparts kinetic energy to the fluid as it is drawn in from the impeller eye (centre) and is forced outward through the impeller vanes to the periphery. As the fluid exits the impeller, the fluid kinetic energy (velocity) is then converted to (static) pressure due to the change in area the fluid experiences in the volute section. Typically the volute shape of the pump casing (increasing in volume), or the diffuser vanes (which serve to slow the fluid, converting to kinetic energy in to flow work) are responsible for the energy conversion. The energy conversion results in an increased pressure on the downstream side of the pump, causing flow.

2) General Symptoms of Cavitation and its effects on Pump Performance and Pump Parts
   a) Perceptible indications of the cavitation during pump operation are more or less loud noises, vibrations and an unsteadily working pump. Fluctuations in flow and discharge pressure take place with a sudden and drastic reduction in head rise and pump capacity. Depending upon the size and quantum of the bubbles formed and the severity of their collapse, the pump faces problems ranging from a partial loss in capacity and head to total failure in pumping along with irreparable damages to the internal parts. It requires a lot of experience and thorough investigation of effects of cavitation on pump parts to clearly identify the type and root causes of cavitation.

3) A detailed description of the general symptoms is given as under. Reduction in capacity of the pump:
   a) The formation of bubbles causes a volume increase decreasing the space available for the liquid and thus diminish pumping capacity. For example, when water changes state from liquid to gas its volume increases by approximately 1,700 times. If the bubbles get big enough at the eye of the impeller, the pump “chokes” i.e. loses all suction resulting in a total reduction in flow. The unequal and uneven formation and collapse of bubbles causes fluctuations in the flow and the pumping of liquid occurs in spurts. This symptom is common to all types of cavitations.

4) Decrease in the head developed:
   a) Bubbles unlike liquid are compressible. The head developed diminishes drastically because energy has to be expended to increase the velocity of the liquid used to fill up the cavities, as the bubbles collapse. As mentioned earlier, The Hydraulic Standards Institute defines cavitation as condition of 3 % drop in head developed across the pump. Like reduction in capacity, this symptom is also common to all types of cavitations.
   b) Thus, the hydraulic effect of a cavitating pump is that the pump performance drops off of its expected performance curve, referred to as break away, producing a lower than expected head and flow.

5) Abnormal sound and vibrations:
   a) It is movement of bubbles with very high velocities from low-pressure area to a high-pressure area and subsequent collapse that creates shockwaves producing

abnormal sounds and vibrations. It has been estimated that during collapse of bubbles the pressures of the order of 104 atm develops.

b) The sound of cavitation can be described as similar to small hard particles or gravel rapidly striking or bouncing off the interior parts of a pump or valve. Various terms like rattling, knocking, crackling are used to describe the abnormal sounds. The sound of pumps operating while cavitating can range from a low-pitched steady knocking sound (like on a door) to a high-pitched and random crackling (similar to a metallic impact). People can easily mistake cavitation for a bad bearing in a pump motor. To distinguish between the noise due to a bad bearing or cavitation, operate the pump with no flow. The disappearance of noise will be an indication of cavitation.

c) Similarly, vibration is due to the uneven loading of the impeller as the mixture of vapor and liquid passes through it, and to the local shock wave that occurs as each bubble collapses. Very few vibration reference manuals agree on the primary vibration characteristic associated with pump cavitation. Formation and collapsing of bubbles will alternate periodically with the frequency resulting out of the product of speed and number of blades. Some suggest that the vibrations associated with cavitation produce a broadband peak at high frequencies above 2,000 Hertz. Some suggest that cavitation follows the vane pass frequency (number of vanes times the running speed frequency) and yet another indicate that it affects peak vibration amplitude at one times running speed. All of these indications are correct in that pump cavitation can produce various vibration frequencies depending on the cavitation type, pump design, installation and use. The excessive vibration caused by cavitation often subsequently causes a failure of the pump's seal and/or bearings. This is the most likely failure mode of a cavitating pump.

6) Damage to pump parts:

a) Cavitation erosion or pitting

1) During cavitation, the collapse of the bubbles occurs at sonic speed ejecting destructive micro jets of extremely high velocity (up to 1000 m/s) liquid strong enough to cause extreme erosion of the pump parts, particularly impellers. The bubble is trying to collapse from all sides, but if the bubble is lying against a piece of metal such as the impeller or volute it cannot collapse from that side. So the fluid comes in from the opposite side at this high velocity and bangs against the metal creating the impression that the metal was hit with a "ball pin hammer". The resulting long-term material damage begins to become visible by so called pits, which are plastic deformations of very small dimensions (order of magnitude of micrometers). The damage caused due to action of bubble collapse is commonly referred as Cavitation erosion or pitting.

b) Mechanical deformations

1) Apart from erosion of pump parts, in bigger pumps, longer duration of cavitation condition can result in unbalancing (due to un-equal distribution in bubble formation and collapse) of radial and axial thrusts on the impeller. This unbalancing often leads to following mechanical problems:
2) Bending and deflection of shafts,
3) Bearing damage and rubs from radial vibration,
4) Thrust bearing damage from axial movement,
5) Breaking of impeller check-nuts,
6) Seal faces damage etc.

7) These mechanical deformations can completely wreck the pump and require replacement of parts. The cost of such replacements can be huge.

c) Cavitation corrosion

1) Frequently cavitation is combined with corrosion. The implosion of bubbles destroys existing protective layers making the metal surface permanently activated for the chemical attack. Thus, in this way even in case of slight cavitation it may lead to considerable damage to the materials. The rate of erosion may be accentuated if the liquid itself has corrosive tendencies such as water with large amounts of dissolved oxygen to acids.

d) Cavitation – heart attack of the pump

a) Thus fundamentally, cavitation refers to an abnormal condition inside the pump that arises during pump operation due to formation and subsequent collapse of vapor filled cavities or bubbles inside the liquid being pumped. The condition of cavitation can obstruct the pump, impair performance and flow capacity, and damage the impeller and other sensitive components. In short, cavitation can be termed as "the heart attack of the pump".

D. Refrigeration / Compressors:

1) The Refrigeration Cycle

a) A thorough understanding of the role of a refrigeration compressor cannot exist without a discussion of the refrigeration cycle, which essentially consists of the transformation of a liquid to a gas and back again.
There are five main steps to a refrigeration circuit: evaporation, compression, condensing, receiving and expansion.

b) Evaporation: Liquid refrigerant enters the evaporator. It absorbs heat when it evaporates, which produces cooling. The refrigerant from the evaporator is fed to a tank as a weak or saturated superheated gas. The pressure in the tank rises until it equals the pressure in the evaporator. Refrigerant flow stops and the temperature in both tank and evaporator both rise to ambient.

c) Compression: To maintain the necessary lower pressures and lower temperatures, a compressor is needed to remove the vapor. Because the refrigeration circuit is closed, equilibrium is maintained. That means that if the compressor removes vapor faster than it can be formed, the pressure will fall and with it the temperature in the evaporator. Alternately, if the load on the evaporator rises and the refrigerant evaporates quicker, the temperature and pressure in the evaporator will rise. The energy that a compressor requires is called compression input and is transferred to the refrigeration vapor.

d) Condensing: After leaving the compressor, the refrigerant moves to the condenser, which gives off heat that is transferred to either air or water having a lower temperature. The amount of heat given off is the heat absorbed by the refrigerant in the evaporator plus the heat created by compression input. The byproduct of this is that the vapor changes to a liquid, which is then sent to the receiver.

e) Receiving: The pressure in the receiver is higher than the pressure in the evaporator because of compression, and thus must be lowered to match the evaporative pressure. This is achieved through the use of an expansion valve.

f) Expansion: Before the liquid enters the expansion valve, the temperature will be just under the boiling point. Suddenly reducing the pressure in the expansion valve causes the liquid to boil and evaporate. This evaporation takes place in the evaporator and the circuit is complete.

g) There are many different temperatures involved in the operation of a refrigeration plant, but in principle there are only two pressures: evaporating pressure and condensing pressure.

2) Types
The main types of refrigeration compressors are reciprocating, screw, scroll and centrifugal. They are used in refrigeration, heat pumps, and air-conditioning applications, such as food processing, ice rinks and arenas, and pharmaceutical manufacturing.
   a) Rotary Screw Compressors
      1) Rotary screw compressors have screw spindles that compress the gas as it enters from the evaporator. The screw compressor features smooth operation and minimal maintenance requirements; typically these compressors only require changes in oil, the oil filter and the air/oil separator. Microprocessor-based controllers are also available for standard rotary compressors, which allow the rotary to remain loaded 100 percent of the time. There are two types of rotary screw compressors: single and twin.
   b) Reciprocating Compressors
      1) A reciprocating compressor uses a piston-actuated unloading mechanism with spring-loaded pins to raise the suction valve plate from its seat, allowing the unit to be used at any pressure ratio. This action is similar to an internal combustion engine in a car. This type of compressor is efficient at both full- and part-load operation. Further advantages include simple controls and the ability to control the speed through the use of belt drives. The reciprocating compressor is used in low-horsepower applications.
   c) Scroll Compressors
      1) Scroll compressors work by moving one spiral element inside another stationary spiral to produce gas pockets that, as they become smaller, increase the pressure of the gas. During compression, several pockets are compressed at once. By maintaining an even number of balanced gas pockets on opposite sides, the compression forces inside the scroll balance and reduce vibration inside the compressor. This type of compressor uses the scroll design instead of a fixed cylinder or a piston or single-sided compression mechanism, eliminating wasted space in the compression chamber and eliminating the need to compress gas again and again during the cycle (recompression). This reduces energy use.
   d) Centrifugal Compressors
      1) Centrifugal compressors compress refrigerant gas through the centrifugal force created by rotors that spin at high speed. This energy is then sent to a diffuser, which converts a portion of it into increased pressure. It does this by expanding the region of the flow volume to slow the flow velocity of the working fluid. Diffusers may use airfoils, also known as vanes, to improve this. Centrifugal compressors are suited for compressing large volumes of gas to moderate pressures.

(Source: www.ehow.com)

E. Chillers/Condensers

1) Absorption Chiller Maintenance - Heat Transfer Components

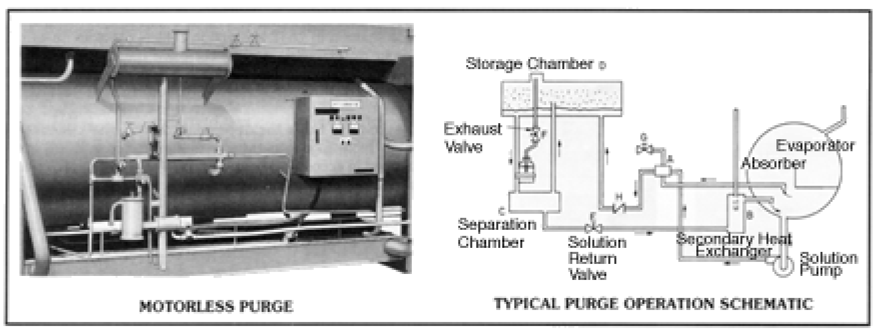
a) The life, performance, and cooling capacity of absorption equipment hinges on keeping heat transfer surfaces free of scale and sludge. Even a thin coating of scale can significantly reduce capacity. Therefore, cooling tower water chemistry is critical, and failure to properly treat this water could void manufacturer warranties.

b) Scale deposits are best removed chemically. Sludge is best removed mechanically, usually by removing the headers and loosening the deposits with a stiff bristle brush. The loosened material is then flushed from the tubes with clear water.

2) Absorption Chiller Maintenance Purging Non-condensable Gases

a) All absorption chillers must be purged of non-condensable gases to maintain performance. The three methods used are steam jet, solution jet (or "motor less purge"), or a vacuum pump, with the vacuum pump being by far the most common.

b) Non-condensable gases migrate to the area of lowest pressure in the absorption chiller (the evaporator) where a small portion of the vapor is extracted and condensed in the purge unit using cooling water. Non-condensables are then evacuated by the vacuum pump. In normal operation, the purge system should operate about one hour a week. The vacuum pump oil level should be observed, maintained, and changed as necessary. Oil purge pump motor bearings should be inspected and replaced, and the belt adjusted as needed. In addition, the vacuum pump should be flooded with oil during seasonal shutdown to prevent internal corrosion.



a) Purging of non-condensables can be accomplished using a "motorless purge"

b) Where motorless purging is used, an optional vacuum pump can also be used for evacuation.

c) In all cases, the operator should log purge operation and monitor purge operation trends. Increasing purge operation signals increasing in-leakage of air and moisture. (*Source: tristatapogee.net)*

d) Industrial water chillers are available with a choice of two types of refrigerant condensers: Water-Cooled or Air-Cooled.

e) **It is important to choose the right type of condensing medium for the environment the water chiller will operate in. Ill suited condensers may affect process cooling and thus affect production quality.**

f) **Refrigerant condensers are necessary to remove latent heat from the high pressure refrigerant gas. This heat is introduced by the compressor.**

g) The condenser is a heat exchanger where refrigerant gas flows on one side and the condensing medium (air or water) flows on the other side. The latent heat from the refrigerant gas is transferred to the condensing medium. As the heat is transferred to the condensing medium, the refrigerant gas cools and “condenses” into a liquid.

h) Low temperature liquid refrigerant is required to chill the process water.

i) A basic example is where the facilities that do not have adequate water supplies from tower or city water supplies will find that an air-Cooled condenser is better suited than a water-cooled condenser because an air-cooled condenser does not require an external water supply.

3) The two condenser types include:

a) Water-Cooled**.** These condensers use a tube and shell heat exchanger where plant water circulates on one side and refrigerant on the other.

b) Air-Cooled. These condensers use a fined tubed heat exchanger and motor driven fans or centrifugal blowers to move air through the condenser.

SELECT A WATER-COOLED CONDENSER... IF:

1. Adequate water supplies are available from tower, city or well sources.
2. Water supply is of good quality.
3. Heat recovery is not practical or unimportant.
4. Plant ambient temperatures consistently exceed 95°F.
5. Ambient air is polluted with large dust and dirt particles.

ADVANTAGE & DISADVANTAGES

1. Offer lower capital investment.
2. Operates more efficiently on hot summer days.
3. Easier to operate.
4. Does not offer summer ventilation.

SELECT AN AIR-COOLED CONDENSER... WHEN:

1. Adequate water supply not available from tower or well sources.
2. Water supply is not of good quality.
3. Heat recovery is practical and important.
4. Plant ambient temperature will not consistently exceed 95°F.
5. Ambient air is not polluted with large dust and dirt particles.

ADVANTAGE & DISADVANTAGES

1. Somewhat more costly to purchase and operate.
2. Gives less cooling on hot summer days.
3. Consumes more electricity.
4. Offers summer ventilation and winter supplement heating.

(Source: www.advantageengineering.com)

F. Cooling Towers

1) What is Enthalpy?

a) Enthalpy is the heat content or total heat contained in a substance at any given temperature.

2) What is a (wet, atmospheric) cooling tower?

a) A cooling tower is a heat rejection device, which extracts waste heat to the atmosphere though the cooling of a water stream to a lower temperature. The type of heat rejection in a cooling tower is termed "evaporative" in that it allows a small portion of the water being cooled to evaporate into a moving air stream to provide significant cooling to the rest of that water stream. The heat from the water stream transferred to the air stream raises the air's temperature and its relative humidity to 100%, and this air is discharged to the atmosphere. Evaporative heat rejection devices such as cooling towers are commonly used to provide significantly lower water temperatures than achievable with "air cooled" or "dry" heat rejection devices, like the radiator in a car, thereby achieving more cost-effective and energy efficient operation of systems in need of cooling. Think of the times you've seen something hot be rapidly cooled by putting water on it, which evaporates, cooling rapidly, such as an overheated car radiator. The cooling potential of a wet surface is much better than a dry one.

b) Common applications for cooling towers are providing cooled water for air-conditioning, manufacturing and electric power generation. The smallest cooling towers are designed to handle water streams of only a few gallons of water per minute supplied in small pipes like those might see in a residence, while the largest cool hundreds of thousands of gallons per minute supplied in pipes as much as 15 feet (about 5 meters) in diameter on a large power plant.

c) The generic term "cooling tower" is used to describe both direct (open circuit) and indirect (closed circuit) heat rejection equipment. While most think of a "cooling tower" as an open direct contact heat rejection device, the indirect cooling tower, sometimes referred to as a "closed circuit cooling tower" is nonetheless also a cooling tower.

d) A direct, or open circuit cooling tower is an enclosed structure with internal means to distribute the warm water fed to it over a labyrinth-like packing or "fill." The fill provides a vastly expanded air-water interface for heating of the air and evaporation to take place. The water is cooled as it descends through the fill by gravity while in direct contact with air that passes over it. The cooled water is then collected in a cold water basin below the fill from which it is pumped back through the process to absorb more heat. The heated and moisture laden air leaving the fill is discharged to the atmosphere at a point remote enough from the air inlets to prevent its being drawn back into the cooling tower.

e) The fill may consist of multiple, mainly vertical, wetted surfaces upon which a thin film of water spreads (film fill), or several levels of horizontal splash elements which create a cascade of many small droplets that have a large combined surface area (splash fill).

f) An indirect, or closed circuit cooling tower involves no direct contact of the air and the fluid, usually water or a glycol mixture, being cooled. Unlike the open cooling tower, the indirect cooling tower has two separate fluid circuits. One is an external circuit in which water is recirculated on the outside of the second circuit, which is tube bundles (closed coils) which are connected to the process for the hot fluid being cooled and returned in a closed circuit. Air is drawn through the recirculating water cascading over the outside of the hot tubes, providing evaporative cooling similar to an open cooling tower. In operation the heat flows from the internal fluid circuit, through the tube walls of the coils, to the external circuit and then by heating of the air and evaporation of some of the water, to the atmosphere. Operation of the indirect cooling towers is therefore very similar to the open cooling tower with one exception. The process fluid being cooled is contained in a "closed" circuit and is not directly exposed to the atmosphere or the recirculated external water.

g) In a counter-flow cooling tower air travels upward through the fill or tube bundles, opposite to the downward motion of the water. In a cross-flow cooling tower, air moves horizontally through the fill as the water moves downward.

h) Cooling towers are also characterized by the means by which air is moved. Mechanical-draft cooling towers rely on power-driven fans to draw or force the air through the tower. Natural-draft cooling towers use the buoyancy of the exhaust air rising in a tall chimney to provide the draft. A fan-assisted natural-draft cooling tower employs mechanical draft to augment the buoyancy effect. Many early cooling towers relied only on prevailing wind to generate the draft of air.
i) If cooled water is returned from the cooling tower to be reused, some water must be added to replace, or make-up, the portion of the flow that evaporates. Because evaporation consists of pure water, the concentration of dissolved minerals and other solids in circulating water will tend to increase unless some means of dissolved-solids control, such as blow-down, is provided. Some water is also lost by droplets being carried out with the exhaust air (drift), but this is typically reduced to a very small amount by installing baffle-like devices, called drift eliminators, to collect the droplets. The make-up amount must equal the total of the evaporation, blow-down, drift, and other water losses such as wind blowout and leakage, to maintain a steady water level.

3) Some useful terms, commonly used in the cooling tower industry:
   a) Drift - Water droplets that are carried out of the cooling tower with the exhaust air. Drift droplets have the same concentration of impurities as the water entering the tower. The drift rate is typically reduced by employing baffle-like devices, called drift eliminators, through which the air must travel after leaving the fill and spray zones of the tower.
   b) Blow-out - Water droplets blown out of the cooling tower by wind, generally at the air inlet openings. Water may also be lost, in the absence of wind, through splashing or misting. Devices such as wind screens, louvers, splash deflectors and water diverters are used to limit these losses.
   c) Plume - The stream of saturated exhaust air leaving the cooling tower. The plume is visible when water vapor it contains condenses in contact with cooler ambient air, like the saturated air in one's breath fogs on a cold day. Under certain conditions, a cooling tower plume may present fogging or icing hazards to its surroundings. Note that the water evaporated in the cooling process is "pure" water, in contrast to the very small percentage of drift droplets or water blown out of the air inlets.
   d) Blow-down - The portion of the circulating water flow that is removed in order to maintain the amount of dissolved solids and other impurities at an acceptable level.
   e) Leaching - The loss of wood preservative chemicals by the washing action of the water flowing through a wood structure cooling tower.
   f) Noise - Sound energy emitted by a cooling tower and heard (recorded) at a given distance and direction. The sound is generated by the impact of falling water, by the movement of air by fans, the fan blades moving in the structure, and the motors, gearboxes or drive belts. *(Source: www.cti.org)*

G. Troubleshooting:

1) <u>A/C System Troubleshooting</u>

The following is an general A/C system troubleshooting guide. Realize that it is generic and many of the things listed here may not apply to all types of systems.

Symptom / Possible Cause	Solutions
<u>Low Compressor Discharge Pressure</u> 1. Leak in system 2. Defective expansion valve 3. Suction valve closed 4. Freon shortage 5. Plugged receiver drier 6. Compressor suction valve leaking 7. Bad reed valves in compressor	**<u>Repair</u>** 1. Repair leak in system 2. Replace valve 3. Open valve 4. Add Freon 5. Replace drier 6. Replace valve 7. Replace reed valves
<u>High Compressor Discharge Pressure</u> 1. Air in system 2. Clogged condenser 3. Discharge valve closed 4. Overcharged system 5. Insufficient condenser air 6. TXV stuck in closed position 7. Failed condensing fan.	**<u>Repair</u>** 1. Recharge system 2. Clean condenser 3. Open valve 4. Remove some refrigerant 5. Install large fan 6. Replace TXV 7. Replace condensing fan
<u>Low Suction Pressure</u> 1. Refrigerant shortage 2. Worn compressor piston 3. Compressor head gasket leaking 4. Kinked or flattened hose 5. Compressor suction valve leaking 6. Moisture in system 7. Trash in expansion valve or screen	**<u>Repair</u>** 1. Add refrigerant 2. Replace compressor 3. Replace head gasket 4. Replace hose 5. Change valve plate 6. Replace drier 7. Replace drier
<u>High Suction Pressure</u> 1. Loose expansion valve 2. Overcharged system 3. Expansion valve stuck open 4. Compressor reed valves 5. Leaking head gasket on compressor	**<u>Repair</u>** 1. Tighten valve 2. Remove some refrigerant 3. Replace expansion valve 4. Replace reed valves 5. Replace head gasket
<u>Compressor Not Working</u> 1. Broken belt 2. Broken clutch wire or no 12v power 3. Broken compressor piston 4. Bad thermostat 5. Bad clutch coil 6. Low Refrigerant - low pressure switch has cut off clutch power	**<u>Repair</u>** 1. Replace belt 2. Repair wire or check for power 3. Replace compressor 4. Replace thermostat 5. Replace clutch coil 6. Add refrigerant

Evaporator Not Cooling	Repair
1. Frozen coil, switch set too high 2. Drive belt slipping 3. Hot air leaks into car 4. Plugged receiver drier 5. Capillary tube broken 6. Shortage of refrigerant 7. High head pressure 8. Low suction pressure 9. High suction pressure 10. Defective expansion valve 11. Frozen expansion valve	1. Turn thermostat switch back 2. Tighten belt 3. Check for holes or open vents4. Replace drier 5. Replace expansion valve 6. Add refrigerant 7. See problem #2 8. See problem #3 9. See problem #4 10. Replace expansion valve 11. Evacuate and replace drier
Frozen Evaporator Coil 1. Faulty thermostat 2. Thermostat not set properly 3. Insufficient evaporator air	**Repair** 1. Replace thermostat 2. Set to driving condition 3. Check for excessive duct hose length, kink or bend.

Source: www.clarks-garage.com

h) **Methods of Refrigerant Leak Detection**

1) One of the most difficult areas of sealed system servicing can be trying to find a refrigerant leak. The leak may exist within a series of tubing that may be up to hundreds of feet long, or in a component that is not readily accessible, or may even be totally concealed. It could be in an operating or safety control such as a pressure switch or possibly right under your nose and you wouldn't even suspect it. As we all know, refrigerant leak detection can sometimes be a **serviceman's nightmare**.
   a) Having the proper test equipment is at least half of the battle. Unfortunately there are so many methods of leak detection and so many types of test equipment and unfortunately, not just one fits every situation. Decisions need to be made as to the method used and the type of equipment needed for every leak you need to find.
   b) **The sole purpose of this section is to help make you aware of the different methods available and to help you decide on which method is most appropriate to use in different situations.**
   c) All of these conditions make leak testing one of the **most challenging tasks** faced by service technicians today. The newer EPA rules are now requiring service technicians to find leaks that are excessive of the law, thus not allowing technicians the choice of just adding refrigerants every so often to keep the system in operation. Add to this the cost of refrigerants today and it becomes imperative that *refrigerant leaks must now be found.*
   d) As you know, there are several methods used to find leaks. Some of the most popular methods are listed below. They are not in any particular order because each leak is unique to the situation at large.

2) Bubble Test (Soap Solution)
   a) A soap solution can be used when you know the approximate area where a leak may exist because of sealed service repair recently done or an electronic leak detector has indicated a leak exists in a particular area of the sealed system.
   b) For example, if you repaired a leak, or replaced a component, or know that a system has a leak somewhere and/or you observe an area of the system that

is oil coated, you would probably use a soap solution, in that area, to test for and pinpoint a leak. It is the simplest and least expensive (material wise) method known today. It may however be more expensive to use, because of labor costs, if the technician does not have any idea where the leak could be.

c) Soap solutions are available in many different types. Some have a brush applicator and others have a dabber (an absorbent ball attached to a stiff wire inside of the cap.) Some brands may even have a spray applicator to quickly cover large areas of tubing in a short amount of time. This is an advantage but is also messy and time consuming to clean up.
d) Some soap solutions even have an antifreeze base to prevent them from freezing in the winter time. Others may have a lower density to make them even more sensitive to very tiny leaks.

3) Some pointers when using soap solution:
   a) If the system does not contain sufficient pressure for leak detection, the refrigerant can be recovered from the system and the system re-pressurized with dry nitrogen to increase the pressure, making it more a probable and less time consuming way of pin-pointing the leak.
   b) **WARNING:**
   c) Do not pressurize the system or component to be checked, more than the manufactures leak testing standards. This pressure is usually stated on the name plate as factory test pressures. If it is not stated on the nameplate, a safe pressure is <u>usually</u> less than 150 psig
   d) There may be times in which an oil spot is noticed in an area of the sealed system. This is usually a suspect that a refrigerant leak is present in that area. A soap solution can help to pin-point the leak.
   e) Holding the dabber against the suspected leak for a period of time may provide better results for small leaks.

4) Water Immersion Method
   a) This method can only be used if the system is small enough to be emerged in a tank of water or if the suspected leak exists in a component that can be cut from the system, sealed and pressurized with a high pressure, dry nitrogen charge. That system or component of the system is then submerged into a water tank. Then the technician watches for bubbles escaping from the leak.

5) **Some pointers when using the submersion method:**
   a) A detergent can be added to the water to decrease surface tension, which helps to prevent the leaking gas from clinging to the side of the component.
   b) Hot water in the tank sometimes helps to increase the pressure inside the component or piping system. If dry nitrogen is used, this does not help because nitrogen does not increase significantly. If refrigerant is contained in the system or component, it may help considerably to increase the pressure and increase the chance of finding the leak.

6) Halide Torch
   a) A halide torch is an inexpensive leak detector that is fast and reliable, but can only be used to detect chlorinated refrigerants. It can be used to detect leaks as small as ½ ounce per year.

b) A halide torch works on the principle that air is drawn over a copper element heated by a hydrocarbon fuel. If halogenated refrigerant vapors are present, the flame changes from a blue color to a bluish green color.
c) It is not as sensitive as electronic leak detectors and is somewhat awkward and could be dangerous because of the open flame.

7) Dye Interception Method
   b) This is method in which a dye is inserted into the system in hopes that some day, the leak allows the escape of a colored dye where the leak exists. This dye becomes visible after a period of time, notifying the technician where the leak is.
   c) Ultraviolet leak detection dyes are also available. These dye kits sometime requires more expensive equipment to detect the leak. This may include an ultraviolet lamp, ultraviolet dye, and some method of getting the dye into the system without letting any moisture or air into the system. These dye methods may be more time consuming because of the time it takes to leak the dye and be visible to the human eye.
   d) Some considerations when using a dye might be:
      1) The dye may be considered a contaminate to the sealed system and is difficult to get into the system without moisture contamination. Even the slightest bit of moisture is detrimental to the longevity of any sealed system.
      2) This method can be (and usually is) a mess and normally requires some type of clean up. The dye usually ends up in your test equipment (gauge manifold and/or refrigerant hoses) and is usually a time consuming mess to clean up
      3) This method is usually time consuming because it could take several hours or days for the dye to leak from the leak source indicating a leak.
      4) This method also means you have to have access to all of the system, which may limit its use

8) Standing Hold Test
   e) This method consists of pressurizing the system with a high pressure, dry nitrogen gas. A pressure, usually between 100 to 200 psig, for a period of time and then identify whether or not the pressure drops during this time. The higher the pressure, the faster you can determine if a leak is present. Fortunately, dry nitrogen experiences very little pressure changes when it is exposed to small temperature changes.

9) **WARNING:**
   a) Do not pressure the system or component, to be checked, more than the manufactures leak testing standards. This pressure is sometimes stated on the nameplate as test pressures but if not, using less than 150 psig is usually safe
   b) The disadvantage of this method of leak detection is that it can only be used if you have a system that can be shut down for a period of time (usually overnight or longer.) This can be very time consuming because some low-level leaks may require a holding period of up to 48 hours or more. It's not that you have to stay with the system for that period of time, it's just the fact that the system may need to be out of operation for that amount of time.

c) The advantage however is that this method will positively identify whether or not a leak exists by monitoring pressure drop. If any pressure drop occurs, it means a leak is definitely present. The disadvantage: This method does not identify where the leak exists, only if a leak is or is not present.

10) Isolation of the Sealed System

a) This is a time consuming method of the standing hold test but is sometimes your only choice. It is usually used when you have no physical access to components in which you suspect are leaking or when you want to identify which part of the system contains the leak. Some examples might be: a concealed refrigerant line, an in-wall condenser, an in-wall evaporator, or any component in which you do not have access to.

b) This process would include isolation of the component (suspected of leaking) from the rest of the system. This is done by breaking that part of the system apart from the rest of system, sealing it, and pressurizing only that component with dry nitrogen. Then use the standing hold test covered before. If the system's pressure drops fast, there is a large leak present in that component or section of the system. If the system's pressure drops slowly, there is a small leak present. If the pressure remains the same, that component does not leak.

c) This method can limit your leak detection labor time only if the system can be out of order for a period of time. Once the component leaking is identified, determine if repairs can be made or not. If not, that particular component can be replaced if it at all possible.

d) A process tube adapter kit could save you some time. It can be quickly connected to the part of the system that has been cut out. This eliminates having to make a mechanical or brazed connection.

11) Electronic Leak Detectors

a) Using an electronic leak detector is generally the fastest way to find an unknown leak.

b) They can be used to quickly find a leak, or to find the area in which the leak exists, in a sealed system when you don't even know where to start. An electronic leak detector gets you really close to the leak. After you find the area in which the leak is detected, you can usually decrease the sensitivity of the some types of detectors to pin point the area of the leak. The leak area is then coated with soap solution to verify the exact point of the leak.

c) Electronic leak detectors must be designed to detect a certain type of or multiple types refrigerant, i.e. (CFC, HFC, HFCF, etc.)

12) **Warning:**

a) You must be careful because you can waste a lot of time if you're using a detector that is not compatible with the refrigerant that is contained in the system you are leak testing.

b) Know your leak detector's capabilities and also what it is not capable of detecting.

c) Carbon monoxide and alcohol can affect the sensitivity of most electronic leak detectors. Be sure neither is present when leak detecting.

d) Operation usually depends on a variation of current flow caused by ionization of decomposed refrigerant between two oppositely charged platinum electrodes.

e) Most electronic leak detectors **are not recommended to be used** in atmospheres that contain **flammable or explosive vapors**. The sensor operates at extremely high temperatures. If this sensor comes in contact with a combustible gas, **an explosion will occur.** This can be very dangerous and costly. It will probably ruin your electronic leak detector and/or possibly damage or destroy a building because of an explosion. Most manufactures will not honor warrantee products against abuse, and exposing a refrigerant sensor to combustible gases, constitutes abuse.

13) Some Pointers when using electronic leak detectors**:**

a) If the leak is suspected to be very small, it may be possible to enclose the suspected area for a period of time to allow the leaking refrigerant time to accumulate. When accumulated, it is then more readily sensed by the detector.

b) This may be done by:

   a) Wrapping a suspected leak in cellophane and leaving it pressurized with a refrigerant charge for a period of time. Then using an electronic leak detector, cut the cellophane at the bottom while using an electronic detector to detect any refrigerant that may have accumulated in the pouch over time.

   b) It is permissible to add a little vapor R-22 to a system and then re-pressurize the system to a higher pressure by adding nitrogen to the system containing the R-22 holding charge. This increases the chance of finding the leak and is considered, by the EPA, as “De Minimus Release” (a good faith effort of finding a leak that may prevent future refrigerant venting through a leak that is not found.)

   c) If a refrigerant component or piping section that is suspected of leaking, is inside a compartment (such as a freezer/refrigerator compartment or a small room) and a leak is suspected in that part of the system. That section could be easily isolated by closing a door and trapping the components in an enclosed space.

   d) If the detectors alarm goes off, you have verified the leak exists in that component, tubing or area.

   e) Again, re-pressurizing the system to a higher pressure and of course, having refrigerant in the system, will accelerate the process.

   f) Refrigerant has a higher specific volume than air; therefore refrigerants will fall when exposed to atmospheric pressures. This means leak detecting on the bottom sides of the piping or components will be more effective in detecting a leak and will save you time.

(Source: www.bacharachtraining.com)

6. Boilers

A. The Laws of Energy: Thermodynamics

1) **Energy**
Energy is defined as the ability to do work. There are two basic types of energy, kinetic energy and potential energy.

2) **Kinetic energy**
Kinetic energy is energy in motion. For example water spilling over a dam can be harnessed to do work since it is in motion. Since the water is moving it is said to have kinetic energy. Heat and light are other examples of kinetic energy.

3) **Heat**
Heat is a measure of the total amount of kinetic energy that a group of molecules or atoms has because of the random movement of the molecules.

4) **Temperature**
Temperature is the average (as opposed to the total) amount of kinetic energy that a group of molecules or atoms has because of random movement of the molecules.

5) **Potential energy**
Potential energy is stored energy. For example the water backed up behind the dam is not doing work, but could do work if released. Chemical energy, the energy stored in chemical bonds is potential energy as is the electrical energy stored in a battery. All chemical reactions, indeed just about the entire living world, are governed by two basic laws of energy or thermodynamics.

6) **Thermodynamics**
Thermodynamics is the branch of science dealing with the laws and theories related to energy in the universe. There are two main laws of thermodynamics, the first and second law. There also is a third law as well which says that absolute zero exists, but it is really a consequence of the other two so we will not deal with it here.

7) **First law of thermodynamics**
The First Law of Thermodynamics says that energy under normal conditions cannot be created or destroyed, simply transformed from one type of energy to another. Thus a chemical reaction such as lighting a match does not create new energy but only converts one type of energy to another. What's happening with the match is that as the match is burnt, potential energy is released and converted to heat and light, kinetic energy. In the cell there are many types of energy transformations: light to chemical (photosynthesis), chemical to chemical (cellular respiration), chemical to electrical (nervous system), and chemical to mechanical (muscles). So the first law is of fundamental importance.

8) **Second law of thermodynamics**
The second law is a bit more complex than the first law, but basically it says that any time you do work, including any time you make an energy transformation, some of the starting energy is going to be lost as heat. So when you drive a car some of the gasoline's energy is lost right a way as heat, some gets turned into mechanical energy to move the car. Even some of this mechanical energy is also lost as heat.

For instance if you feel your car's tires at the end of a trip they will be hot from friction with the road. This heat is an energy loss and is a consequence of the second law.

(Source: www.staff.jccc.net)

7. Plumbing

A. Flush Valve Maintenance:

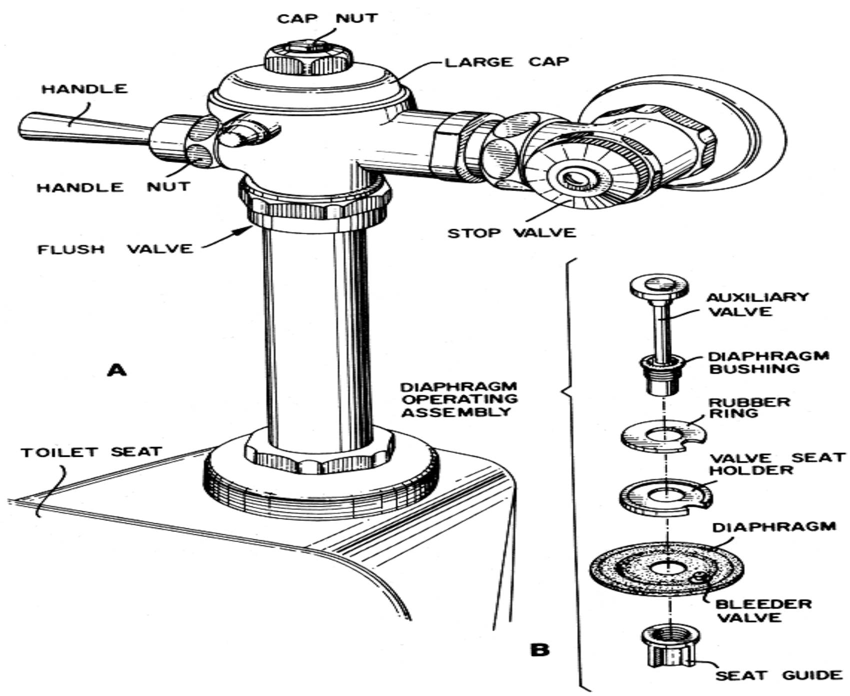
1) How To Repair Diaphragm on Flush Valve
    a) The roaring ferocity of a torn flushometer diaphragm can be nerve-racking.
    b) Here's how the beast malfunctions: you trip the handle; the diaphragm rises inside the valve, roars, and then snaps closed before enough water has passed through. The only way you can get a full flush is to hold the handle until the job is done. And that's a pain. So read on.
    c) Shut off water supply at stop valve or at main cutoff in basement.
    d) Tape jaws of wrench or large cap to prevent damage to fixtures.
    e) Place wrench on large cap of cover assembly, and turn in Counterclockwise direction until assembly is removed (Fig. 83A).
    f) Place fingers inside flush valve and find diaphragm. Vulcanized into it is a brass fitting held in place by several rings. This is called the diaphragm operating assembly (Fig. 83B).
    g) Remove assembly.
    h) Examine diaphragm for holes or tears.
    i) Unscrew diaphragm bushing from seat guide in counterclockwise direction.
    j) Remove diaphragm and replace with new one, making sure that the strainer side of the bleeder valve is next to seat guide holder.

2) Reassemble into flush valve as follows:
    a) Place seat guide downward into valve
    b) Place auxiliary valve seat in center.

3) Replace cover assembly, first lubricating threads with petroleum jelly. Tighten slowly.

4) Turn on water and test.

5) After procedure is completed, it may be necessary to adjust the length of the flush as follows:
    a) Remove cap nut.
    b) Insert screwdriver through top of valve seat assembly and turn in a clockwise and counterclockwise direction until proper flush is achieved. Clockwise turning shortens the flush and counterclockwise turning lengthens the flush.
    c) Replace cap nut.
    d) Test flush.



(Source: www.accuratebuilding.com)

B. Aerators:

1) Most faucets have an aerator. No matter which faucet you have, nearly all have a little device in the spout, this is the aerator, that mixes air with the out- pouring water. This device is designed to reduce the splattering that would otherwise happen when the faucet is turned on, plus it saves water too.
   a) Determine which faucets have reduced water flow. Make sure the shut-off valve (typically under the sink) is turned on all the way. If this is the case and the water flow is restricted, then the problem is most likely trash or other debris caught in the faucet aerator located right above where the water comes out of the faucet stem.
   b) Remember how all these parts came off. With the water shut off to the faucet in question, try to unscrew the aerator housing with your fingers.
   c) If the aerator does become loose, carefully keep unscrewing it and take it completely off. DO NOT loose track of how the parts came off because you will need to know how to replace all of them correctly for the faucet to work right.
   d) Use a rag when using pliers to loosen the aerator so you don't mar up the faucet. If the aerator does not unscrew using your fingers, no sweat, grab a rag and a set of pliers. Using the rag to keep from marring up the aerator housing, apply pliers and loosen it.
   e) Notice the screen. That's where the debris will build up. With the aerator completely unscrewed and with knowledge of which parts came out first, flush all debris from the little screen which is the main part of an aerator. This is likely the reason for the water flow reduction.
   f) Rinse water over the screen and all other parts in the aerator. Make sure you don't drop any parts.

g) After cleaning all parts, reassemble the aerator parts in the correct order back into the faucet. Gently tighten with fingers.
h) Turn the water back on and hopefully see the smooth flowing water coming from your once clogged faucet.

(Source: www.ehow.com)

C. Soldering

1) Caution: Please read our safety information before attempting any testing, maintenance or repairs. Wear eye protection and gloves when soldering and when working with flux. Flux is a toxic substance. Some equipment may rely on a cold water supply. Take appropriate steps to shut down any equipment that may be adversely affected by shutting off the water supply. Such equipment includes, but is not limited to, a boiler or other heating system.
   a) Note: Because you are working with a flame, often in a confined space, be aware of flammable materials near where you are working. In some cases, you may need to set up a non-flammable heat shield between the solder joint and flammable material nearby. Check with your local authority for applicable codes about the work you wish to perform and the necessity of permits before you begin your project.
   b) When copper pipes are fitted together, there is a very small gap between the two pieces. When the pipes are heated, and solder is touched to the pipes, the solder melts and is drawn up into the gap through capillary action. Once the gap is filled, and the heat removed, the solder forms a seal and makes a watertight joint.
   c) Soldering pipes is easy once you get the hang of it. The key is to recognize that you are heating the pipes, not the solder. The heated copper melts the solder. Follow the steps in this guide and you should be able to make watertight joints. It is recommended that you practice a few times on some spare parts until you feel confident.

2) How To Solder Copper Pipes
   a) Remove all burrs from the inside and outside edges of the pipe with a deburring tool. Small burrs can result in variety of problems in the lifespan of the water supply system.
   b) Clean the outside of the pipe to a brilliant shine with a copper pipe cleaning brush, or simply use steel wool or emery cloth. If the copper is not clean, the solder may not bond properly and the joint may leak.
   c) Clean the inside of the female fitting in the same way as in step 1.
   d) Apply acid-free flux to both the outside of the male fitting and the inside of the female fitting. Flux further cleans the copper plus helps to prevent oxidation as the pipe heats up. If the pipe becomes oxidized, the joint may leak.
   e) Join the two pieces securely together.
   f) Unroll about four inches of solder and straighten it. You will use the roll or container as a handle when applying the solder.
   g) Light the torch and apply the flame to the joint. Move the flame around to ensure that you heat the metal on the opposite side from you.
   h) When the flux begins to bubble and spit, touch the tip of the solder to the joint. The solder should melt immediately and disappear into the joint. Remove the heat. Work quickly because the pipe's temperature will drop quickly. Move the tip of the solder around the entire joint to ensure that solder

fills in all the way around. If the joint stopped taking up solder because the solder was not melting, then quickly add more heat so that more solder can be applied.

i) Once the joint will take no more solder it will build up outside of the joint and begin to drip. Use a damp rag to wipe the joint clean.

3) Notes:
   a) Always check for leaks after the pipe has cooled.
   b) If you overheat the copper, it will oxidize and that prevents the solder from bonding.
   c) If the joint leaks, you must open the joint, remove all the solder and start over by cleaning the metal and applying flux. It may be easier to start over with new fittings.
   d) Always use lead-free solder.
   e) Make sure the pipes are completely dry or it will interfere with the bonding of the solder.
   f) If you cannot completely stop the flow of water from the pipe you are working on, it may be impossible to heat the pipe hot enough. Take a wad of white bread (without the crust) and stuff it into the pipe. This will hold the water back for a minute or two. After that the bread will dissolve harmlessly in the pipe and is easily flushed out.
   g) If you use MAPP gas instead of propane, it burns much hotter and will heat the copper very quickly compared to propane. If you are used to propane, practice with MAPP before beginning work.

(Source: www.acmehowto.com)

D. Backflow

1) **What is Backflow?**

A backflow prevention device is used to protect water supplies from contamination or pollution. Many types of backflow prevention devices also have test cocks so that they can be tested or examined to ensure that they are functioning properly.

a) The **Environmental Protection Agency** (EPA) holds local water suppliers responsible for maintaining a certain amount of purity in potable water systems. Many states and/or local municipalities require annual testing of backflow prevention assemblies.
b) Backflow prevention protects the potable water system from minor, moderate, and severe hazards. There are over 10,000 reported cases of backflow contamination each year. Some cases can be fatal. Backflow devices are required by law where needed and must be installed in accordance with plumbing or building codes. A backflow assembly has test cocks and shut-off valves and must be **tested each year**, if relocated or repaired, and when installed.

ALL IRRIGATION SYSTEMS ARE CONSIDERED A HIGH HAZARD.

2) Common Irrigation Backflow Prevention Assemblies

a) A Pressure Vacuum Breaker (PVB) is a type of backflow prevention device, used to keep non-potable (or contaminated) water from entering the water supply. A PVB is similar to an atmospheric vacuum breaker (AVB), except that the PVB contains a spring-loaded poppet. This makes it acceptable for applications that are high hazard or where valves are downstream. Pressure vacuum breakers must be protected from freezing when installed outdoors. PVBs usually have test cocks, to which specially-calibrated gauges are attached, in order to ensure that they are functioning properly.

PVBs are manufactured by **Watts**, **Febco**, **Zurn** and other manufacturers. Backflow prevention devices such as PVBs are regulated by the International Plumbing Code, but may also be required by government regulations.

a) A reduced pressure (RP) backflow prevention device is a device used to protect the potable water supply from contaminated water. An RP valve consists of an automatic pressure relief valve in between two check valves. The pressure relief valve opens to the atmosphere in the event of a reduction in the pressure differential between the first two chambers of the device.

The assembly is considered to provide redundant means of protection because: (1) check valves keep water flowing in one direction only, and; (2) the relief valve will operate in the event the supply pressure drops below atmospheric pressure.

Reduced pressure backflow preventers can be abbreviated RP, RPP (Reduced Pressure Principle) and RPZ (Reduced Pressure Zone). RP assemblies protect against backsiphonage and backpressure, and may be used where a potential hazard exists. RP valves can be found in commercial buildings, hospitals, and industrial applications.

(Source: www.abpa.org)

Under no circumstances should a backflow device be bypassed.

8. Electrical

A. Conduit installation

1) Several general requirements apply to all types of conduit installation. All runs must be installed as a complete system before any conductors are pulled into them. In other words, a run of conduit (to include conduit, fittings, and supports) must be complete before the conductors are installed. A run of conduit should be as straight and direct as possible. When a number of conduit runs are to be installed parallel and next to each other, install them all at the same time. The minimum size raceway that can be installed is generally 1/2-inch electrical trade size. There are exceptions to this rule depending on specific locations. The exceptions for each type are outlined in the NEC.

2) All types of conduit must be reamed after they have been cut. Conduit threaded in the field must be threaded with a die that has a 3/4-inch taper per foot. Also, never use threaded couplings with running threads. Running threads weaken the conduit and may come loose. Threaded couplings and connectors used with any type of conduit must be made with tight connections. When the couplings or connectors are to be buried in concrete or masonry they must be the concrete-tight type. When installed in wet locations, they must be the watertight type.

3) Fittings for EMT are of two general types ¾ watertight fittings that may be used outdoors or in any location and fittings that provide strong mechanical and electrical connections, but may be used only in dry locations. The watertight fittings join sections of tubing by means of a five-piece compression fitting. (Figure 4-1).

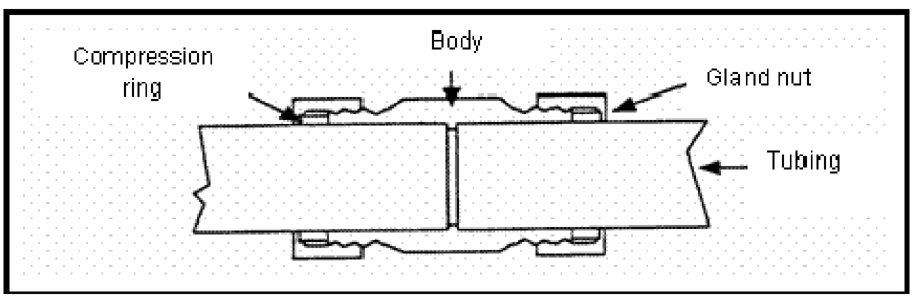


Figure 4-1. Five-piece compression fitting

4) To put a watertight fitting together, use the following steps:
   Step 1. Place a gland nut and compression ring over the end of each piece of tubing (in that order).
   Step 2. Slip a double-threaded ring (called the body) over the end of each section.
   Step 3. Screw the gland nuts onto the body and tighten them to squeeze the compression rings. The rings form a watertight seal.

A similar fitting having only three pieces is used to make a watertight joint to metal boxes (Figure 4-2).

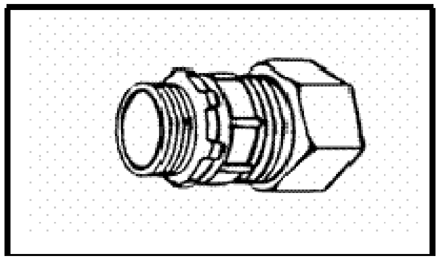


Figure 4-2. Three-piece fitting

5) To make a watertight joint to a metal box, use the following steps:
   Step 1. Place the large nut and compression ring on the end of the EMT.
   Step 2. Place the double-threaded body over the end.
   Step 3. Screw the nut onto the body to squeeze the compression ring and make a watertight seal.
   Step 4. Use the exposed threads on the body to secure the EMT to a weatherproof box using a locknut and bushing (Figure 4-3).

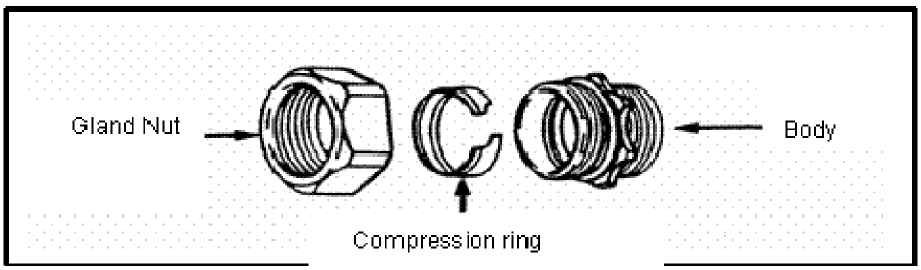


Figure 4-3. Opened three-piece fitting

Fittings for use in dry locations are simpler to use and less expensive. One type consists of a sleeve and two or four setscrews (Figure 4-4).

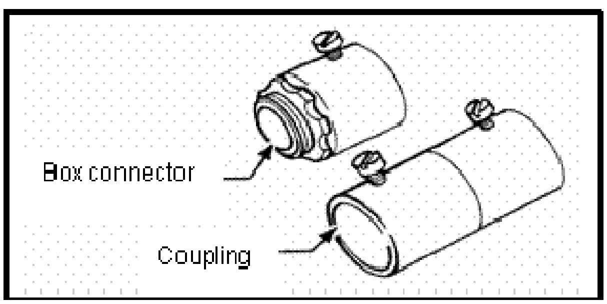


Figure 4-4. Dry-locations fittings

Another form of coupling is made by using a plain sleeve and an indenting tool (Figure 4-5).

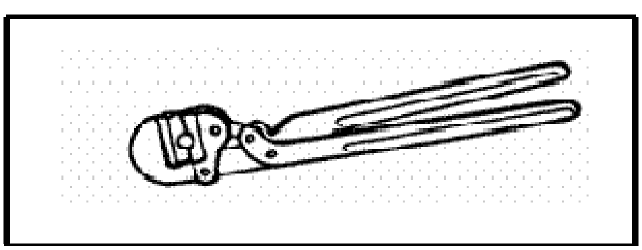


Figure 4-5. Plain sleeve and indenting tool coupling

To put on an indented coupling, use the following steps:

Step 1. Place the sleeve over the ends to be joined.

Step 2. Use the indenting tool to make indents in the coupling and the tubing to secure the joint. The tool makes two indents at once on either side of the coupling (Figure 4-6).

Step 3. Use the tool twice, 1/4 turn apart, on each end of the coupling, to make a total weight of eight indents at the joint.

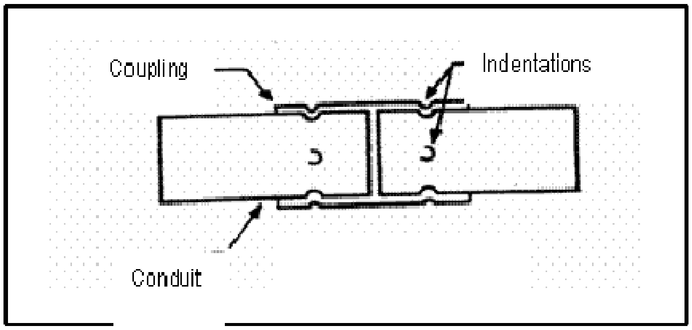


Figure 4-6. Indenting tool

Fittings used for rigid-steel and PVC conduit are similar to those used for EMT. Threaded and threadless couplings and connectors are available for use with rigid-steel and PVC conduit and PVC. The threadless fittings are installed in the same way as those for EMT. The advantage of using threadless couplings and connectors is that threading the conduit is not required. Because EMT has a thin wall, it cannot be threaded, thus threaded couplings cannot be used with EMT (Figure 4-7).

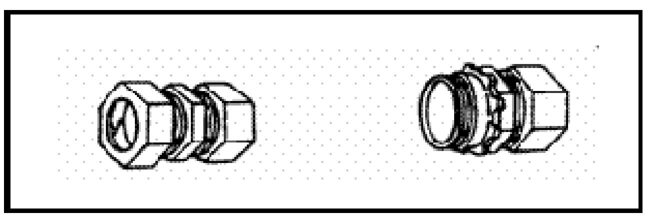


Figure 4-7. Threadless couplings and connectors

On rigid steel conduit threaded couplings are screwed onto the threaded ends of the conduit and tightened with a pipe wrench (Figure 4-8).

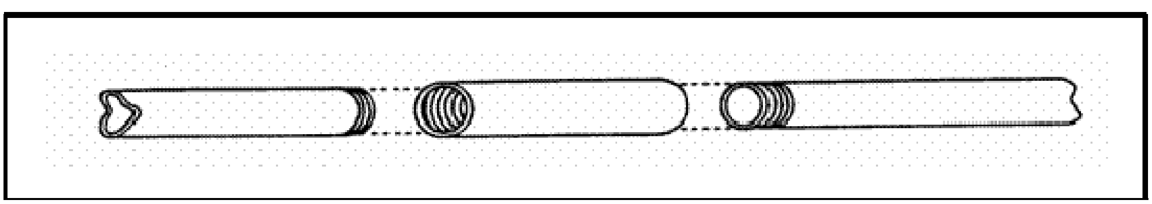


Figure 4-8. Threaded coupling

Rigid-steel and PVC conduit is connected to electrical boxes by locknuts (Figure 4-9). The locknuts are tightened against each side of the box wall. The bushing is placed over the end of the conduit to provide the conductor with protection from physical damage.

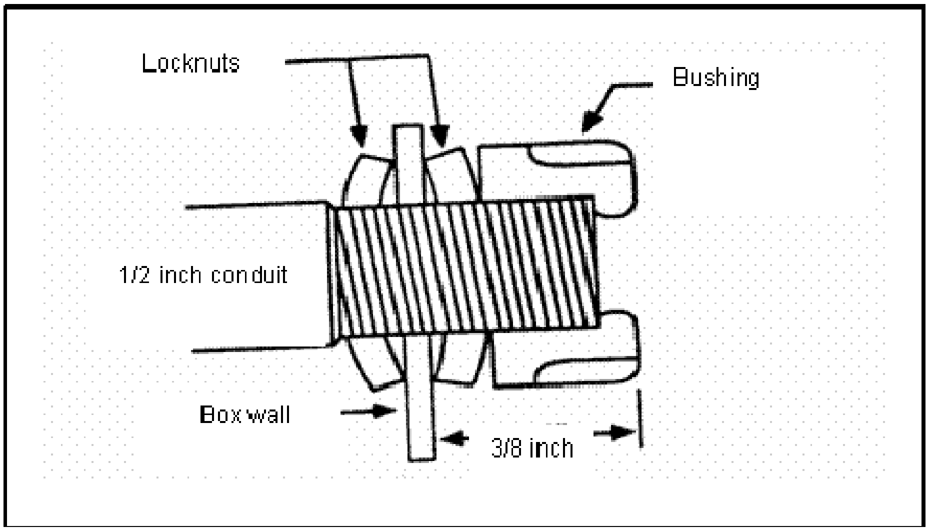


Figure 4-9. Box connector

Fittings for flexible metallic conduit are either internally or externally attached to the conduit. The internal type is designed to screw into the spiral of the conduit. This type of connector covers the end of the conduit completely, protecting the conductors from contact with the cut edge of the conduit. Externally attached connectors are secured to the conduit with clamping screws (Figure 4-10).

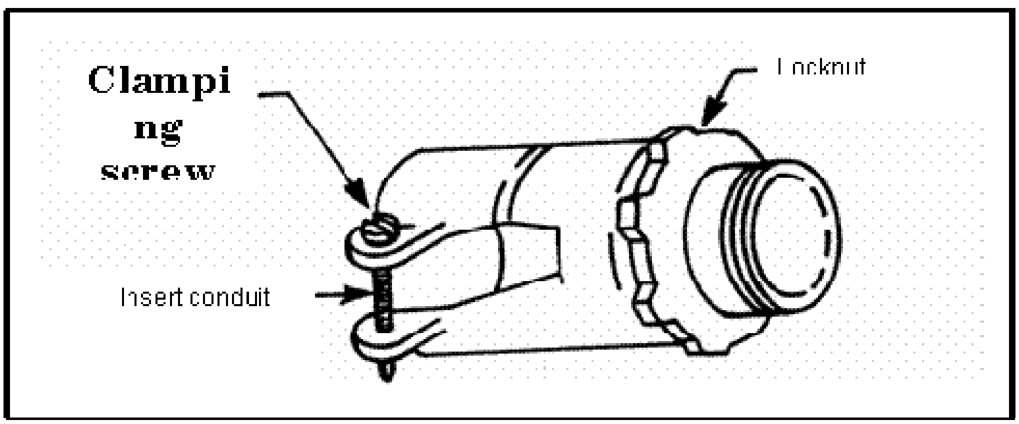


Figure 4-10. Flexible metallic conduit connector

a) When using these connectors, make sure that the cut end of the conduit is pushed as far as possible into the connector, covering the cut end and protecting the conductors from damage.
b) The spiral construction of flexible metallic conduit causes it to have a higher electrical resistance per foot than solid metallic conduit. For this reason, flexible metallic conduit should not be used as a grounding conductor. An additional bare or green-insulated grounding conductor should be included with the current-carrying conductors in flexible conduit installations.

A special type of metallic flexible metallic conduit is made for use in wet areas. It is called liquid-tight. Liquid-tight fittings are available for use with this conduit (Figure 4-11).

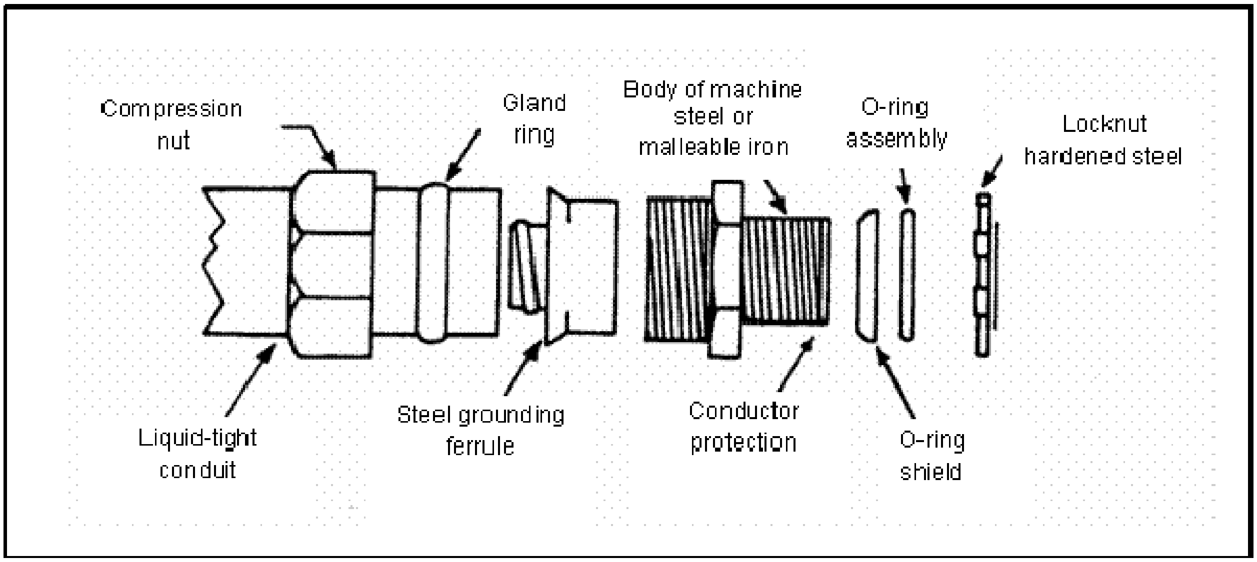


Figure 4-11. Flexible metallic, liquid-tight conduit connector

Connections are made in PVC conduit by cementing two pieces of PVC together (Figure 4-12). Joints must first be coated with primer. The cement used is actually a solvent that softens the plastic at the joint and allows the softened areas to flow together to form a weld. The resulting joint is watertight and strong. PVC conduit can be cut readily with any fine-tooth saw.

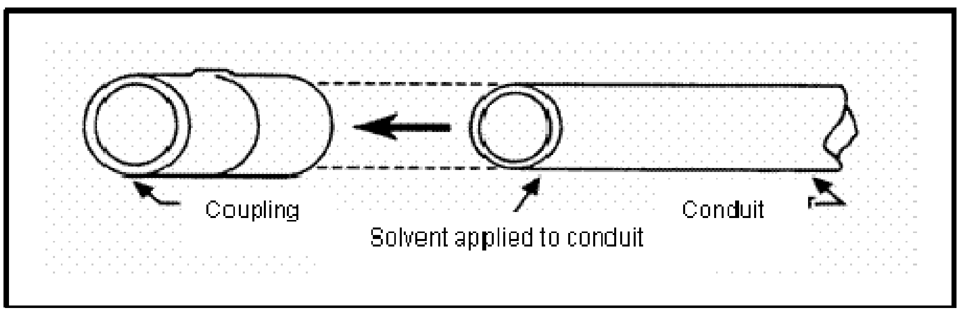


Figure 4-12. PVC coupling

6) When you run conduit from one point to another, you often need to make more turns (total of 360°) than the NEC allows in a single run. When this is the case, you can use a fitting called a conduit body. A conduit body, as defined in the NEC, is "a separate portion of a conduit or tubing system that provides access through a removable cover to the interior of the system at a junction of two or more sections of the system or at a terminal point of the system." Figure 3-3, page 3-3, shows some of the more common conduit bodies and covers.
7) A conduit body is put in conduit between two outlets to keep the bends within NEC limits for a single run (Figure 4-13). As you can see, the run below has bends that total 360º, which is all the NEC permits. Therefore, a conduit body had to be installed so that the conduit could be continued to the box on the right.

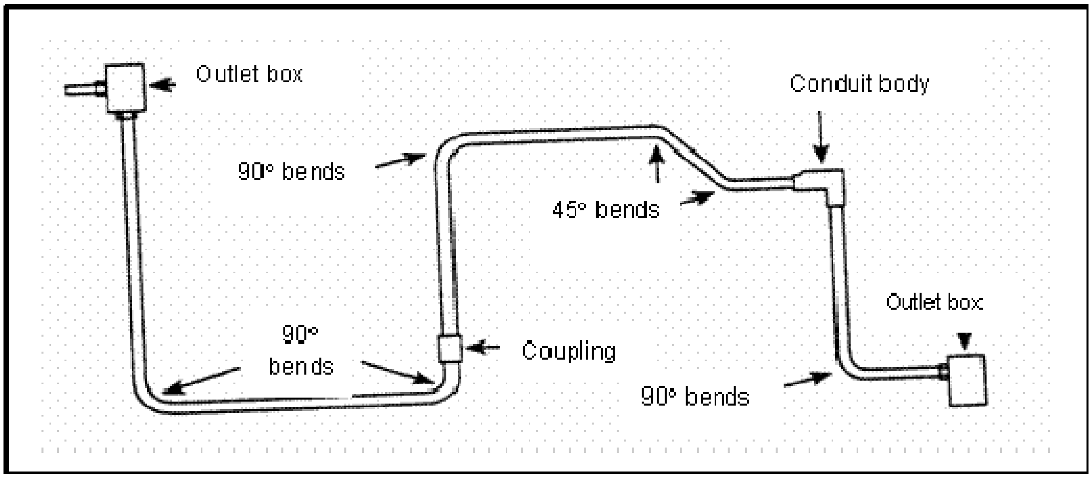


Figure 4-13. Conduit body usage

Conduit must be supported by straps or hangers throughout the entire run (Figure 4-14).

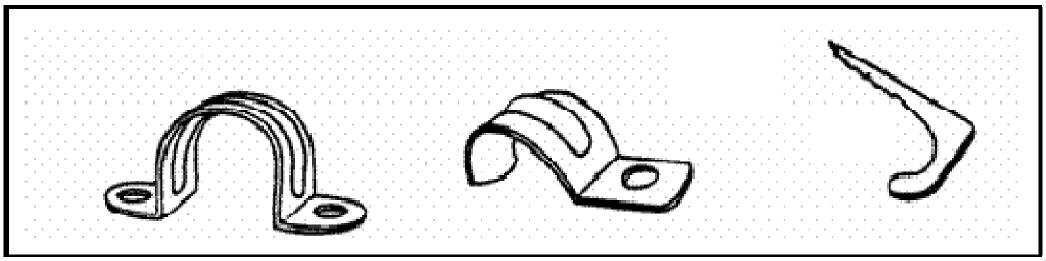


Figure 4-14. Conduit supports

8) On a wooden surface, nails or wood screws can be used to secure the straps. On brick or concrete surfaces, you must first make a hole with a star or carbide drill and then install an expansion anchor. Use an expansion tool to force the anchors apart, forming a wedge to hold the anchor in the hole. Secure the strap to the surface with machine screws attached to the anchor. On tile or other hollow material, secure the straps with toggle bolts. If the installation is made on metal surfaces, you can drill holes to secure the straps or hangers with machine or sheet-metal screws.
9) The number of supports needed depends on the type of conduit being used. Holes or notches in framing members may serve as supports. EMT requires supports within 3 feet of each outlet box, junction box, cabinet, or fitting and every 10 feet thereafter. Rigid-steel conduit must also be supported within 3 feet of a box. The distance between supports may be increased to 20 feet on direct vertical runs of rigid-steel conduit from machine tools and other equipment if threaded couplings are used and the riser is supported at each end. PVC must be supported as in Table 4-1.

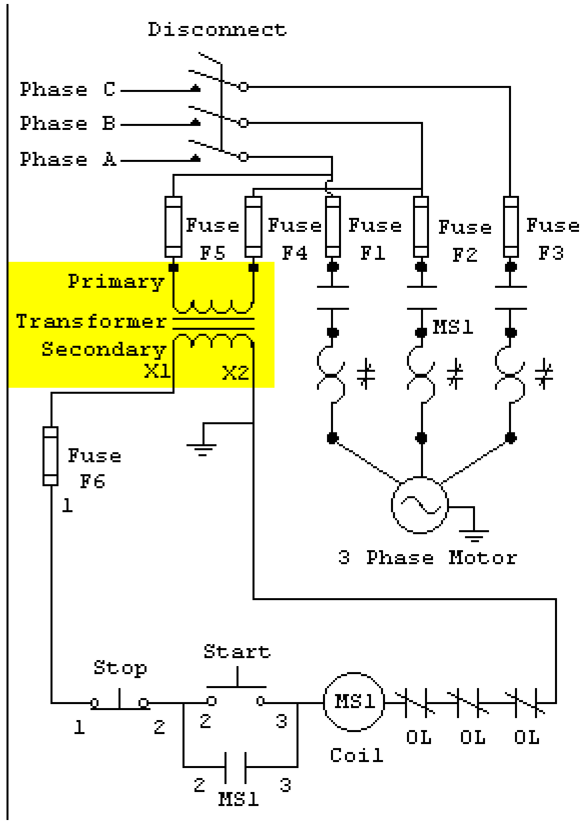
Table 4-1. Supporting distances for PVC

Conduit Size	Maximum Space Between Supports
1/2 to 1 inch	3 feet

1 1/4 to 2 inches	5 feet
2 1/2 to 3 inches	6 feet
3 1/2 to 5 inches	7 feet
7 inches	8 feet

10) In addition, PVC must be supported within 3 feet of each opening. Flexible metallic conduit must be supported at intervals not to exceed 4 1/2 feet and within 12 inches on each side of every outlet box or fitting. Exceptions to this are runs of 3 feet or less where flexibility is needed or 6 feet when connecting light fixtures. After all conduit has been installed, supported, and connected to the boxes, you are ready to install the conductors. *(Source: www.freeed.net)*

B. **Introduction to Transformers**



1) Shown to the right is a schematic of a Three Phase Motor Starter. The area highlighted in yellow is the part of the schematic which contains the control transformer.

2) The Control Transformer is powered by two of the three phases. Here it receives power from phases A and B. This is a single phase transformer and lowers the voltage to a more common value which is useful when adding lights, timers or remote switches not rated for higher voltages. Transformers have a primary side and a secondary side. The primary side is the higher voltage side and the secondary side is the lower voltage side.

3) Control transformers are rated in volt amps (VA). The control transformer primary side voltage must match the incoming line voltage and the secondary side must match the load voltage.

4) The VA rating must be greater than the VA rating of the load. If lights and timers are used the VA rating must be greater than the total load. The Secondary Fuse protects the control circuit and transformer from damage, including fire damage. The VA rating of the transformer is used to properly select the fuses. The fuse must be smaller than the VA rating of the transformer. Calculate the fuse size by first determining the size of the transformer.

5) The VA rating is the math formula used in determining the amperage at a given voltage. A secondary voltage of 120 volts from a 100VA transformer will produce .83 amps... e.g., 100 VA ÷ 120 Volts = .83 Amps. The VA rating is divided by the voltage. The result is the transformer's output amperage. The Secondary Fuse size for a

100VA transformer must be 8/10 Amp or smaller. A fast acting fuse is best. Refer to the NEC.

6) The primary fusing protects the control transformer from damage, including fire damage. The VA rating of the transformer is used to properly select the fuses. The fuses must be matched to the VA rating of the transformer. The VA rating is the math formula used in determining the amperage at a given voltage. A primary voltage of 480 volts for a 100VA transformer will draw .21 amps...e.g., 100 VA ÷ 480 Volts = .21 Amps.
7) The VA rating is divided by the voltage. The result is the transformer's input amperage. The Primary Fuse size for a 100VA transformer must be .21 Amp or 150% larger. Oversizing Primary Fuses is necessary due to the initial load when power is first applied (the initial load is also referred to as "inrush"). A timed delay fuse is best. Refer to the NEC.

(Source: www.exman.com)

C. **Industrial wiring – 3 Phase**

1) **Understanding Industrial Wiring**
WARNING: You should know and understand safety and follow normal safety and OSHA guidelines when working with industrial electricity and your work must conform to local and national building codes and NFPA guidelines.

2) **Why 3-Phase?**
Normal 110V and 220V is like a big strong fellow who is driving in a tent pin. At some point, the amount of work that has to be done can be tougher than what the big fellow can do. With 3-phase, it's like having three guys with sledge hammers, working together, each hitting the tent pin in a rhythm. While each may not be doing as much work as the big fellow, together the three of them can drive in the tent faster because they are hitting it with three small blows for every one time the big guy is hitting the pin, and the total amount of work being accomplished is much greater when added up.

3) **Advantages of 3-Phase**
Often the wiring is smaller, the motor may last longer, and there's a good chance that a lighter motor will outperform and save more energy than a single-phase motor.

4) **Types of 3-Phase Power**
   a) Common 3 Wire Type
   b) Common 4 Wire Type
   c) Special 4 Wire Type
   d) 3 Wire w/Grounded Hot Leg
   e) The type of 3-phase power normally doesn't dictate the operating voltage. Usually, a voltage meter is required to determine the actual voltages available, which will also give you some clues about the type of 3-phase. It is extremely important to perform all the tests, especially if you suspect 3 wire w/grounded hot leg and will be using only two legs or you may create a dead short with your connections.

f) For traditional reasons, 110V/220V are used, but the actual voltage may be 120V/240V or 125V/250V. It will make more sense, especially when discussing 3-phase power, as you will see later.

5) **Common 3 Wire 3-Phase**

a) This is the same as 4 wire 3-phase, and is actually used to describe how the wiring is done. The same voltages and types of service are still available, and is normally only done when the lowest voltage is not required, or for high-voltage 3-phase at 440V and above. For clarity, it is mentioned here, but to understand how it works, see the diagram and details for 4 wire 3-phase.

6) **Common 4 Wire 3-Phase**

a) The leads marked L1, L2, and L3 are hot leads, or "line," and typically, diagrams and schematics will continue to use the numbers, but change the letters to "S" for them after a switch. Sometimes, "M" is used to identify motor leads. "N" is neutral, and is never switched for this type of 3-phase service. Which is which? Actually, it is impossible to really know which is L1, L2, and L3, so we just pick out the three hot leads and start from there.

b) Let's say you check and find that you have 220V 3-phase service. Now, you can get three separate, single-phase 110V circuits by using L1 & N, L2 & N, or L3 & N. Also, you have three separate, two-wire 220V circuits by using L1 & L2, L1 & L3, or L2 & L3. For 3-phase, 220V, you need to use all three leads, L1, L2, and L3. Remember that you can't just decide to use a particular type of power because you want to — the device must be designed to work the way you hook it up.

c) At higher voltages, such as 440V 3-phase, the neutral (N) lead may not be provided, or a separate leads may be supplied for providing a 110V circuit.

d) A special type of 4 wire 3-phase service for 208V is available, too. This is accomplished in a strange way, and is most often used in lighting circuits where 208V two-wire and 3-phase service is desired, along with 110V service. It is less common, but may be found in older buildings and for special applications.

e) 3 Wire w/Grounded Hot Leg is an older type of service. Sometimes, this is provided with 4 wires, so that 110V service can also be provided. This type of service is especially hard to test for, since most folks are not familiar with it. Normally, you have to check for voltage to ground, and the grounded leg will not show any voltage when a meter is used to check from the ground leg to ground. However, this lead can only be used for 3-phase, or a short to ground may occur. Otherwise, this service works like other 3-phase service.

7) **Connecting Motors to 3-Phase**

a) With single-phase and two-wire 220V, either a shaded pole, CSIR, or CSCR motor is used so it starts in the correct direction. One of the advantages of 3-phase is that the timing of the phases automatically make the motor directional. Unfortunately, there is no way to know which way the motor will run ahead of time, so you need to "bump" the motor — turn on the power for part of a second — to see which way it is going to turn. Some pumps and most compressors don't care, and when a motor gets older and starts to it is common to reverse the direction to make the motor last longer. To switch the direction of rotation on a 3-phase motor, simply switch any two leads.

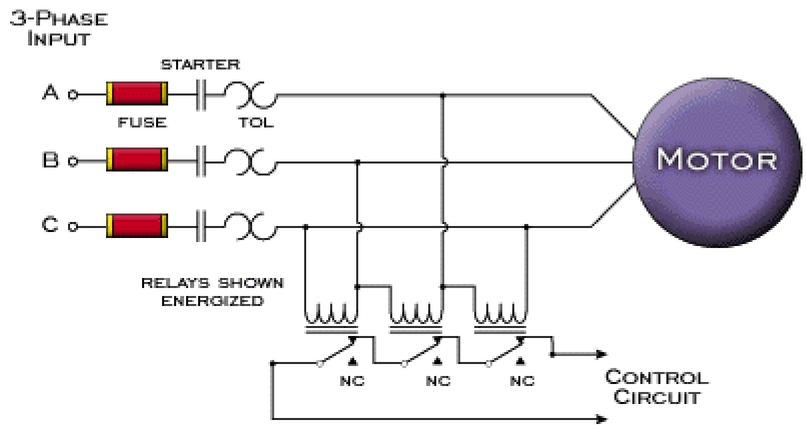
8) **Safety Ground**
   a) Industrial wiring is commonly run inside metal conduits, raceway, or armored cable, and the safety ground accomplished through these metal enclosures. The neutral wire is never used to carry the safety ground. Refer to current NFPA guidelines for proper safety ground installation.
   b) Commercial wiring may have different requirements in your local area. Be certain to check beforehand and do the work in accordance with local building codes. If in doubt, call your building commissioner.

9) **Switches, Controls, and Over-current Protection**
   a) With the exception of 3 wire 3-phase w/grounded hot leg, all three leads that are hot need overcurrent protection and should be switched. Some switches incorporate a starter that has special circuitry to limit the current draw, or apply a higher voltage, when starting the motor.
   b) Some switches and controls will use single-phase, two-wire 220V, or other combinations, which the actual motor or device that uses a lot of power uses 3-phase. For example, a refrigeration compressor that operates on 220V 3-phase may have a 220V 2-wire heater and contactor coil, and a 24V solenoid valve to control the refrigerant from a cold control. Due to this complexity, it is extremely important that you know and understand how to read wiring diagrams and schematics, and be able to determine the voltages and type of power that each control or device uses.

D. **What Is Single-Phasing?**
   1) `Loads using three-phase power sources are subject to loss of one of the three phases from the power distribution system. This condition is known as "single-phasing." The loss of a single phase on a three-phase line may be due to a downed line or a blown pole top fuse on the utility system. Loss of a single phase may also result from a single-phase overload condition causing one fuse to blow, or an equipment failure within the end-user's facility.
   2) The loss of one phase, or "leg," of a three-phase line causes serious problems for induction motors. The motor windings overheat due primarily to the flow of negative-sequence current, a condition that exists anytime there is a phase voltage imbalance. The loss of a phase also inhibits the motor's ability to operate at its rated horsepower.
   3) If single-phasing occurs when a motor is rotating, the torque produced by the remaining two positively rotating fields continues to rotate the motor and develop the torque demanded by the load. The negatively rotating field, the field associated with the lost phase, produces currents in inductive loads resulting in voltages in the faulted leg of the three-phase supply. These voltages may be nearly equal to the phase voltage that was lost. Therefore, detecting a single-phasing condition by measuring the voltages at the motor terminals is usually unproductive.
   4) Three-phase motors may continue to run, but they are not capable of starting on a single phase. If after the overload devices on the energized phases isolate the motor, the motor is not then isolated from the lost phase, later attempting a restart on that single-phase supply will cause the motor to draw locked rotor current.

E. **Protecting Motors from Single-Phasing**

There are a number of ways to protect machines from single-phasing and voltage unbalance. The diagram below shows a simple protection scheme that has been used to protect industrial equipment from damage caused by single-phasing. However, as has already been discussed, regeneration on the missing leg in inductive loads may make it impossible to detect the loss of phase based on voltage alone.



Three-phase motor single-phasing protection can be provided by time-delay overcurrent protection fuses sized at 125 percent of the motor running current. To produce rated torque under single-phasing conditions, motors will draw a line current of 173 to 200 percent of normal. The overload devices will open to protect the machine in this case. However, this will occur only where the motors are being operated at or near their nameplate ratings.

Loss of a single phase to a three-phase motor reduces the power output of that motor to approximately 57 percent. If the motor is lightly loaded, circulating currents may damage or destroy the motor windings without the overload devices removing the motor from the line. This will also occur where motors are oversized for their application. For example, a 5 horsepower motor is used where the load is only 3 horsepower.

To provide adequate protection from single-phasing conditions, the overload devices must be sized to the actual full-load RMS current. This may be determined with a clamp-on meter while the motor is running at its normal full load. For applications where the load is variable, another means of single-phasing protection will be required.

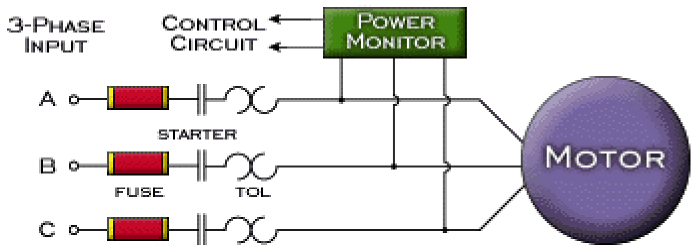
An alternate means of single-phasing protection should also be considered where multiple critical three-phase loads are supplied by a single main service with ground fault protection. A ground fault in one of the loads may cause the time-delay overload protection fuse to clear the overcurrent condition on the faulted phase. However, the overload protection will not clear the ground fault. If the remaining time-delay overcurrent protection fuses do not open before the ground fault protection relay operates, power to the remaining critical loads will be lost.

Integrated circuit technology may provide cost-effective solutions for some phase protection problems. These modules provide a contact closure when voltages of the proper magnitude and phase are present on the monitored line. The relay contacts can be wired into the control logic of the protected load to remove primary power or

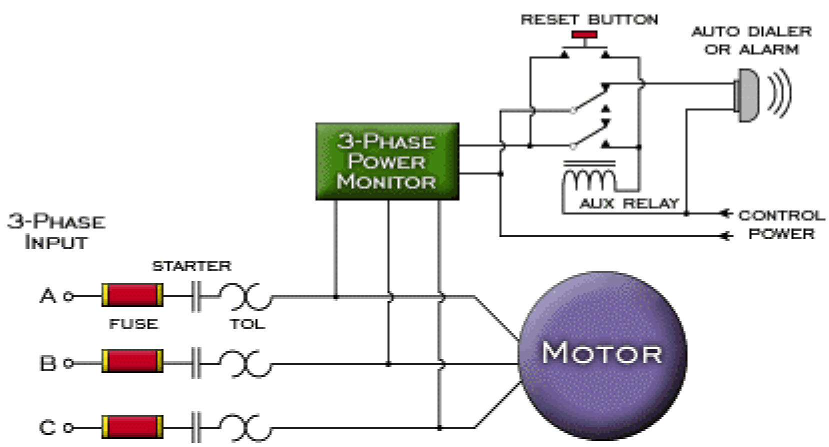
to prevent attempted restarts during single-phasing conditions. These units are small and relatively inexpensive, and may include sensitivity adjustments for various nominal line voltages.
The diagram below shows a typical application with a single three-phase motor load. Note that the input to the phase monitor module is taken from the final set of motor fuses. Connecting the power monitor in this manner allows:

1) installation of the power monitor without disturbing existing protective devices, and
2) detection of any failure inside the system that may cause single-phasing.

Outputs may be wired into a control circuit to trip the motor contactor should a failure occur.



An alternative would be to use the module to trip an audible alarm circuit or automatic dialer as shown in this diagram:



Sensing a single-phase condition is meaningless without a reliable source of tripping control power. It is common practice to derive the control power from control power transformers, which are themselves fed from the bus likely to be affected by the single-phasing condition. The most reliable source of control power is DC supplied by a station battery. If a reliable alternate source of control power is not available, a control power transformer configuration must be designed that will assure sufficient voltage for tripping regardless of which phase has been lost.

Sources: www.diyonline.com; www.wisconsonpublicservice.com

9. Architectural Drawings

A. How to Read Architect's Drawings

1) The first requirement in constructing a building project is to understand architectural drawings (blueprints, or in this article, referred to as plans). Here is a basic overview of reading these plans.

   a) **Cover sheet.** This will contain the project name, the architect's name, address, and contact information, the project location, and the date. This page is very similar to the cover of a book.

   b) **Plan Index.** This page (pages) will have an index of plan sheets (and sometimes their contents). It also will include an abbreviation key, a scale bar with the plan scale indicated, and occasionally design notes.

   c) **Location plan.** This will have an area map, with an enlarged location map, usually giving enough information to locate the project site from nearby towns or highways. This sheet is not found in all sets of plans.

   d) **Site plans.** These pages usually are numbered starting with a "**C**", such as Sheet **"C 001", "C 002**". This will often contain several sheets, showing:
      1) **Topographical Information**. This will indicate to the builder the topography (slopes or flatness) of the site.
      2) **Demolition plan**. This sheet (or sheets) will show the structures or features which will be demolished on the site prior to grading for construction. It will have trees or other items which are to remain noted in the keynotes.
      3) **Site utility plans**. This sheet (sheets) will indicate the location of **existing** underground utilities, so that they can be protected during excavation and construction.

2) **Architectural sheets**. These sheets will usually be numbered "**A**", such as **"A 001"**. These sheets will describe and give measurements for the basic footprint of the building. These plan sheets should include the following.
   a) **Floor plans**. These sheets will show the location of the walls of the building, and identify components like doors, windows, bathrooms, and other elements. There will be dimensions noted as distances between, or from center to center of walls, width of openings for windows and doors, and changes in floor elevations, if the floor is multilevel.
   b) **Ceiling plans**. Here, the architect will show the types, heights, and other feature of ceilings in different locations in the building.
   c) **Roof framing plan**. These pages will indicate the layout for joists, rafters, trusses, bar joists, or other roof framing members, as well as decking and roofing details.
   d) **Finish schedule**. This is usually a table listing the different finishes in each individual room. It should list paint colors for each wall, flooring type and color, ceiling height, type, and color, wall base, and other notes and details for constructing the finish in areas listed.
   e) **Door/Window schedule**. This table will have a list of doors, describing the opening, "hand" of doors, window information (often keyed off of the floor plan, example, window or door type "A", "B", etc.). It will also include

installation details (cuts) for flashings, attachment methods, and hardware specifications. There may also be a separate schedule for window and door finishes. A window example would be "Mill finish, aluminum", a door might be "Oak, natural finish".

1) **Details**. This may include bathroom fixture layouts, casework (cabinets), closet accessories, and other elements not specifically noted on other sheets.
2) **Elevations**. These are views from the exterior, indicating the material used in exterior walls, (brick, stucco, vinyl, etc), the location of windows and doors from a side view, the roof slopes, and other elements visible from the exterior.

3) **Structural plans**. The structural plans usually are numbered beginning with "**S**", as in "**S 001**" These plans include reinforcement, foundations, slab thicknesses, framing materials, (lumber, concrete pilasters, structural steel, concrete block, etc.)
   a) **Foundation plan**. This sheet will show the size, thickness, and elevation of footings (footers), with notes regarding the placement of reinforcing bars (rebar). It will note locations for anchor bolts or weld plate imbeds for structural steel, and other elements. A footing schedule is often shown on the first sheet of structural notes, as well as notes regarding the reinforcing requirements, concrete break strength requirements, and other written statements for structural strengths, and testing requirements.
   b) **Framing plan**. This will indicate the material used for framing the building. This may include wood or metal studs, concrete masonry units, or structural steel.
   c) **Intermediate structural framing plans**. These are used for multistory construction, where each level may require support columns, beams, joists, decking, and other elements.

4) **Plumbing plan**. Plumbing drawing pages are numbered beginning with "**P**". These sheets will show the location and type of plumbing incorporated in the building.
   a) **Plumbing rough-in**. This sheet will show the location of pipes which are to be "stubbed up" to connect the plumbing fixtures to water supply, drain/waste, and vent systems.
   b) **Plumbing floor plan**. This sheet will show the location and type of plumbing fixtures, as well as the route pipes will be run (overhead or through walls) for potable water and drain, waste, and vents.

5) **Mechanical drawings**. Mechanical pages are numbered beginning with "**M**"or "**H**". This sheet (or sheets) will show the location of HVAC (heating, ventilation, and air conditioning) equipment, ductwork, and refrigerant piping, as well as control wiring.

6) **Electrical plan**. The electrical drawings are numbered beginning with "**E**". This sheet (sheets) shows the location of the electrical circuits, panel boxes, and fixtures throughout the building, as well as switchgears, subpanels, and transformers, if incorporated in the building. Special pages found in the electrical plan pages may be **"riser" details**, showing the configuration of power supply

wiring, panel schedules, identifying specific breaker amperages and circuits, and notes regarding types and gauges of wires and conduit sizes.

7) **BMP (Best Management Practices)** drawings, or environmental plans. This sheet will indicate protected areas of the site, erosion control plans, and methods for preventing environmental damage during construction. There may be details in the BMP drawings showing tree protection techniques, silt fence installation requirements, and temporary storm water retainage measures. The requirement for a BMP plan originates under the environmental protection department of your local, state, or national governing authority.
   1) Locate the element of construction you are reviewing to implement a portion of your work. If you are laying out the location of the building, you will first look at the site plan for location of existing buildings, structures, or property lines so you have a reference point to begin measuring to your building footprint. Some plans simply give a coordinate grid position using northings and eastings, and you will need a "total station" surveyor's transit to locate these points. Here are some example steps for laying out a building foot print from architectural plans.

8) **Lay out your building** on the site by either the above referenced plan or the measurements given on the site plan. Measure to locations, preferably corners, on one side of the building, and check for any "checkpoints" to verify the accuracy of your layout. If you cannot absolutely establish an exact building line, you may have to suppose the location is correct and continue. This is widely accepted in cases where the site is very large, allowing for tolerance, but on a crowded lot or site, the location must be exact.

9) **Establish the elevation** you will work from. This may be a height relative to a nearby roadway, or an elevation determined from sea level. Your site plan or architectural floor plan should have a **bench mark**(a bench mark refers to some item, such as a manhole lid or survey waypoint with a known elevation) elevation or a "height above existing grade" as a starting point.

10) **Use your plan to measure the location** of each corner of the building, including offsets. Remember what exact element of construction you are using for your layout. You may mark an *outside wall line*, a *foundation line*, or a *column line*, depending on the type of construction and the most practical element for making subsequent measurements. For instance, if you are building a structural steel building with I-beam columns which require setting *anchor bolts* to secure them, you may begin your building layout with the centerline of these columns, where if you are building a wood-framed residential structure with a monolithic slab floor, the edge of the slab would be your best choice for the initial layout.

11) **Reference the description of various sheets** to find an element of construction you are going to use in the work you will perform. Plumbers use the Architect's floor plan to locate walls so the pipes they stub up will be concealed inside the wall cavity when the building is constructed, then use their plumbing floor plan to find out what types and sizes of pipes are required to service a particular fixture.

12) **Use the dimension scale** where measurements are not provided. As a rule, architectural plans are drawn to a "scale". An example would be, 1 inch equals

10 feet (1"=10'), so measuring between to walls on the plan sheet means for each inch, the distance is 10 feet. A scale rule will make this much easier, but be careful to match the rule scale to the plan's scale. Architects often use a scale of fractions, such as a 1/32 scale, engineers usually use an inch per foot scale. Some plans or details are not to scale, and should be marked "(NTS)".

13) **Read all notes on a page.** Often a particular element has special considerations which are more easily described verbally than drawn, and notes are a tool the architect will use to illustrate them. You may see a table of notes on the side of a sheet, with numbers identifying the note location on the plan (a number with a circle, square, or triangle around it) and a corresponding numbered statement describing the situation on the side of the sheet.

14) **Learn to recognize the different types of lines the architects and engineers may use.** You should have a specific keynote table for section of plans, and this will provide information on the abbreviations, symbols, and specific lines used in each section of the plans. An example would be in the electrical plans, a circuit may have the "**home run**" "leg" (the wire going from the first junction box in a circuit to the panel box (the power source) highlighted or in darker ink than other circuits, and exposed conduits may be indicated by a solid line, and concealed conduits by a dotted or broken line. Because there are many different line usages indicating different type walls, piping, wiring, and other features, you will have to see individual plan page "key notes" to understand them.

15) **Use a "**Builder's**" calculator** to add dimensions when determining distances on your plans. These are calculators which add feet and inches, fractions, or metric measurements. Often, an architect will not give a measurement to a specific plan item, from a baseline such as the "'**OBL**" (outside building line), so you will need to be able to add the distances each feature which has a measurement provided, to get the total distance. An example would be finding the center line of a bathroom wall to locate the potable water pipe stub up. You may have to add the distance given from the OBL to the living room wall, then the distance to a hallway wall, then across a bedroom, to the bathroom wall in question. This might look like **(11' 5*) + (5' 2") + (12' 4")= 28' 11"***.

16) Use **CAD** (Computer Assisted Design) building plans. If you have a set of architectural plans in an electronic form, as on a CD, you will need a version of the original "cad" program which created it to open the files. "AutoCAD" is a popular, but very expensive, professional design program, and the designer will usually include a "Viewer" on the disc which you can install on your computer to view files, so that actual plan pages appear on your screen, but without the full program, you cannot manipulate design components or change the drawings.

Learn how to handle architect's plans. These sets of documents are often very large sheets, about 24" X 36", and full construction sets may include dozens, or hundreds of pages. They are either bound or stapled on the left edge, and allowing them to be torn from the bindings, ripped apart by mishandling, laid out in the sun to fade the ink, or left in the rain can make them difficult to use. These documents can cost hundreds of dollars (US) to replace, so try to protect them, and have a flat, wide, protected work surface to unroll and read them on.

17) Remember that the building plans for a project often include contract documents other than the Architect's Drawings.
18) **Specifications are usually printed and kept in a binder**, and they list descriptions of methods and materials used in the project, as well as testing methods, quality control information, geotechnical data, and other information useful in building the project.

19) Look for notes and symbol referring to "alternate bid items" and "addendums". These may indicate portions of work which are incorporated in the Architect's drawings, but not in the builder's contract to construct, supply, or install. "NIC" is an abbreviation for Not In Contract, which means a certain item will be put in a certain place by the owner after the project is finished. "OFCI" or "GFCI" (Owner Furnished, Contractor Installed, or Government Furnished, Contractor Installed) indicate the item is supplied by the customer, but installed by the contractor. Read and understand all abbreviations used in your plans.

20) **Be careful your set of drawings are** "original size**",** since many sets of plans are provided in "full" and "half" size sets, you will be able to scale distances with full size drawings without needing to calculate the scale via drafting rulers
    a) If the drawings are true half size, you will need to divide your readings from your ruler by 2. Note: most half size drawings do not state they are half size or other. Basically to consider anything a half size drawing, it will normally be less then a 24x18 (Arch C) sized sheet. Keep in mind, sometimes a half size sheet is called a half size even when its plotted from a 30x44 to a 11x17 size set, rendering it no longer a true half size.
        1) When doing actual construction from architect's plans, keep one set onsite to record changes with a red ink pen or pencil. These are called "redline drawings". When a job has been fully constructed, redlines are usually provided back to the drafter. These drawings are called "Record Drawings" (RD's) or "As-Builts". These are the site survey redlines which are different from the original set of drawings (aka corrections).
        2) Use a "triangle" type architect's or engineer's rule for scaling distances on plans. These are shaped so that they offer a flush contact with the plan page so exact positioning of the rule is possible, decreasing the possibility of error.

B. Standard Drawing Symbols

1) Graphic symbols are used on construction drawings to reference other drawings within the set. For example, elevation graphics are used on a floor plan to indicate which walls are shown as elevations. A detail graphic, which is a circle around an area of a drawing with an extension to a number, indicates that this area has been drawn to a larger scale to provide specific details.
2) In order for this system of symbols to work, each drawing within the set has its' own unique number. This is usually a combination of numbers. The number for the individual drawing as well as the page or sheet number on which the specific drawing appears. Individual drawings may be referenced many times throughout a set of construction drawings.
3) Graphic symbols are also used to list drawing notes, identify finishes and revisions. The same graphic is used for one purpose. For example, the same symbol is used

for every revision. It is the number within the graphic that carries its' own specific information.

C. The following are examples of typical drawing symbols:

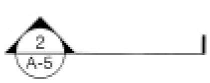
Drawing Title

Each individual drawing throughout a set has its' own number, title and scale.
The top number in the circle indicates the drawing number. In this case the eight means that this is the eighth drawing on the sheet.
The bottom number indicates the sheet number; here it is sheet number A-3.
The title indicates that the drawing is an elevation. The scale of the drawing is shown below.
Drawings on each sheet within the set are numbered in sequence.
The first drawing starts with number one. The second number two. This numbering continues to include the last drawing on that sheet. Drawing number one typically starts at the top left corner of the sheet. The numbering for drawings on the next sheet will start in the same manner.

Elevation

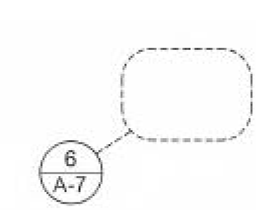
The elevation graphic is typically used on a plan. The drawing on which they appear, floor plan, furniture plan or partition plan, is determined by the company producing the drawings. The arrow around the circle will point to the surface that is shown in elevation. For example, the arrow will point to the specific wall. Or the arrow will point to the front of a cabinet, another arrow (symbol) will point the side, and so on. Each elevation circle will have its own specific number. The top number indicates the drawing number. The bottom number indicates the sheet number. The graphic shown references elevation number 8 on sheet number A-3.

Section



The section symbol is used to show where a section is cut through the construction.
A section graphic is used horizontally or vertically, based on the intent of the information to be provided. The arrow indicates the direction of the view of the section. The top number indicates the drawing number. The bottom number indicates the sheet number. In this case the section will be shown on sheet A-5. It will be the second or number 2 drawing on that sheet.

Detail



The detail symbol is used to indicate where a portion of construction is drawn to a larger scale. A circle or rectangle is placed around this part on a drawing.
Details are typically placed on plan drawings. In some cases, they are also used on elevations or sections when it is necessary to enlarge an area to clearly explain the design and building method.
A detail number is connected to the circle or rectangle. The top number indicates the drawing number. The bottom number indicates the sheet number. In this case the detail will be shown on sheet A-7. It will be the number 6 drawing on that page.

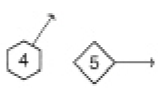
Door Number

Door numbers are used to identify each door separately. Each door has its' own number.
The door number mark is placed next to the door on a plan drawing. It is also used on elevations when doors are shown, as a cross-reference.
Within the construction drawing set, a door schedule is included. This lists each door by number. Detailed information about each door is provided next to each door number.

Revision

A revision graphic is used to indicate that a change was made to a drawing.
The area of a drawing, where a change was made, is enclosed with a bubble. The revision number is placed next to the bubbled area.
The number within the triangle indicates whether it is the first revision (1) made to the drawing, or the second (2), or the third (3) and so on.
The revision graphic is also placed within the drawing sheet border with a date and brief explanation about what the revision entails.

Key Notes



Key note symbols will vary from company to company. Once a symbol is established for keynotes, it is consistent through out the entire set of drawings.
Key notes are commonly used on plan drawings, such as a partition plan or demolition plan.
Each mark has its own specific number. The notes are numbered in sequence.
Each note symbol is placed on the plan with an arrow pointing to the related area.
A specific note number may reference several areas on a drawing.
A legend is provided where each note number is listed along with specific information next to it.
Using key notes simplifies the drawing. The plan is not crowded with notes. Changing the information on a note in a legend once, is easier than trying to change many notes within a plan.

Finishes

Finish symbols will vary from company to company. Once a symbol for finishes is established, it is used consistently throughout the entire set of drawings.
A finish identification symbol is to show where various finishes are applied to surfaces. Each finish used in the project has its' own unique number, or combination of number and letter. The symbols are used on plans, elevations, sections and details.
A finishes schedule is included in the set of drawings. Each symbol number is listed in the schedule with a description of the related material next to it.

Some of the typical finishes for a project are carpet (C-1), vinyl tile (VT-1), paint (PT-8) or (8), plastic laminate (PL-3) or (3).

The symbols shown above are typical to construction drawings.

Source: www.wikihow.com