Bench Jeweler’s Guide to Working with Gold
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Starting to work with gold can be intimidating. It’s more costly than silver and behaves slightly differently at the bench. Fear not. Working with gold is not really all that different than working with silver. In fact, in some cases, it is much easier to work with and has more desirable characteristics.

This guide will introduce you to the terminology used with gold, review the characteristics of different gold alloys and explain how those characteristics differ from those of silver. It will also discuss general information on how to work with gold alloys successfully.

The Karat

If you’re going to work with gold, the first thing you need to understand is the karat.

Karat is a unit for measuring the purity of gold and is expressed with the letter K, which follows a numerical value, e.g. 24K. Karat is not to be confused with carat, which is a measurement of mass used to express the weight of gemstones.

The karat system is divided into 24 parts, each equal to about 4.165%. Pure 99.9% gold is expressed as 24K and is too soft to be used for most jewelry items. To be workable for jewelry, gold is mixed with other metals to form alloys; the amount of pure gold in each of these alloys is expressed by its karat value, for example, 18K and 14K.

The percentage of gold in an alloy is written as a fraction in which the number on the bottom is 24. If the top number is also 24, the fraction is 24/24, which is pure gold. A familiar alloy is 14K. As a fraction, this would be 14/24, which can also be expressed as .583, in other words, 58.3% pure gold. Anything less than 10K, or 41% gold, cannot be legally sold as gold in the United States.

The Pennyweight (dwt.)

The pennyweight is a unit of mass for gold mill products in the U.S. When you order gold sheet or wire, the price will be based on how many pennyweights of gold are in your order. There are 20 pennyweights in a troy ounce of gold, and one pennyweight is equal to .05 ozt or 1.56 grams. When working with gold, it is helpful to use only one system of measure.

Alloys

A gold alloy is a mixture of pure gold and another metal or metals. Alloying does several things to the properties of gold, including increasing its hardness and tensile strength, changing its color and, in most cases, decreasing its melting temperature.
The metals that are mixed with gold to form an alloy vary but usually include silver and copper. Other metals, such as zinc, nickel and palladium, can be added to achieve a certain result, including increasing flow characteristics or acting as a bleaching agent. When one property of a metal is changed, it will affect the entire alloy. There is always a tradeoff. For example, nickel will bleach gold to form a white metal, but it makes the alloy brittle and difficult to work. Palladium can be added to a nickel gold alloy to increase its workability, but it will raise the melting temperature. Knowing the properties of the gold alloy you are using is crucial to working with gold successfully.

The general properties of gold alloys include hardness, melting point and tensile strength.

**Hardness:** the metal's ability to resist abrasion and deformation. Hardness is a variable property, which means that an alloy may possess different levels of hardness that can be manipulated. Heating the metal to an annealing temperature will decrease the alloy’s hardness. Working the metal (e.g. bending, twisting, rolling, forging) will increase its hardness.

**Melting point:** the temperature at which a metal begins to turn from a solid to a liquid.

**Tensile strength:** the maximum amount of stress an alloy can withstand before it breaks. This is also a variable property that will change with the metal's hardness.

Each of these properties is important. Taken as a whole, they will dictate how you work with gold in your designs.

To the right is a chart of the most common gold alloys and how they compare to sterling and fine silver. This is a general guideline. Each alloy’s characteristics will change slightly depending on the refiner it comes from. Because of this, it is not uncommon to change the way you work with gold when you change suppliers or karat values.

Scanning down the hardness column on the graph above, it’s clear that alloys significantly change depending on what is added.

Abbreviations: Au=gold; Ag=silver; Cu=copper; Pd=palladium; Ni=nickel

Note: All values are averages taken from many different manufacturer’s specification sheets and other sources. Due to the multiple ways that an alloy can be formulated, melting temperature, hardness and tensile strength can vary widely.
For instance, the characteristics of 24K gold are drastically changed with an addition of just 8% other metal. The melting temperature decreases, and the alloy becomes harder and slightly more difficult to form. When comparing 14K gold to 24K gold, the melting temperature is 500°F lower, and the metal is seven times harder and has four times the tensile strength.

The color of gold also changes when it is alloyed. 14K gold is much different in color than 24K because it has 41.5% less pure gold. Red golds (pink, rose, etc.) have a higher percentage of copper than yellow gold, which shifts the color to a redder hue. If an alloy has higher silver content, the color will shift toward a light green color.

Since you cannot add enough silver to gold to make a white gold alloy, a bleaching agent must be added. Currently there are two metals used: palladium, which is a member of the platinum group of metals, and nickel.

Most white gold finished jewelry and jewelry components are plated with rhodium, which is another metal of the platinum group. You should take this into account before accepting a repair job on a piece of white gold jewelry because you will most likely need to re-plate the entire piece after the repair.

If you’re working with nickel-based white gold, it’s important to remember that some people have a nickel allergy. If you’re selling your work in Europe, you should be aware of EU regulation EN1811:201, which governs the levels of nickel allowable in products that have prolonged contact with the skin, including jewelry.

**Working with Gold**

**Oxidation/Tarnish**

Oxidation, or tarnish, in precious metal alloys is caused by a reaction between copper and oxygen. The higher the percentage of copper in the alloy (whether gold or silver), the more susceptible the metal will be to oxidation.

With most gold alloys, oxidation over time is not noticeable because the yellow oxide color is not as apparent as it is on sterling silver. As with sterling silver, the oxidation of a gold alloy will accelerate if it is exposed to chemicals such chlorine from swimming pools or hot tubs, household cleaning products, and hand lotions, as well as the wearer’s body chemistry.

**Soldering**

Heat is a catalyst to the oxidation process, and high heat (such as the temperatures used in soldering or annealing) causes what we know as firescale, which is a layer of oxides that forms on the surface of the metal. Most gold alloys do not oxidize as much as sterling silver when soldered or annealed properly. This makes soldering gold alloys a bit easier. The oxides that do form on the surface will generally come off in the pickle bath, and a light buffing will bring up the shine on the surface.
Since pure gold, like pure silver, does not contain copper, it will not form firescale when heated. This is also true for 22K gold because it has very low copper content. This absence of copper also makes it possible to fuse pure gold and 22K gold.

When you move to an 18K alloy, there is enough copper to form firescale during the annealing and soldering processes, and this is even more so with lower karat yellow gold and all red gold alloys.

Protect gold alloys from oxidation with a barrier flux (such as a mixture of boric acid and methyl alcohol, Stop-Ox II, Cupronil® or Firescoff) any time you heat the metal. You will also need to use a flow flux (such as Handy® Flux or My-T-Flux) at the joint when you set your solder in place.

As with all soldering operations, you need to use the right torch for the job at hand. A fuel/oxygen torch is highly recommended when working with gold. It produces a hotter flame than a fuel/air torch, and you can adjust the oxy/fuel mixture to produce a reducing flame. Flux and a reducing flame help combat firescale. Using a torch that is not hot enough can cause the flux to break down, and oxides will begin to form not only on the surface but also in the interior of the metal. This firescale will need to be sanded, filed or ground off, which can be costly in time and in material loss.

**Solders**

Gold solders, like silver solders, are formulated to melt at different temperatures. As when soldering silver, you should use a step-down soldering procedure when there are multiple solder joints on the same piece, especially when the joints are close to each other. Use hard solder on the first joints, followed by medium solder and easy solder (which have progressively lower melt temperatures) on subsequent joints. This will prevent the previous joints from re-melting.

There are two types of gold solders on the market. “Plumb solder” has a gold content equivalent to its karat value. For example, plumb 14K easy solder will have at least 58.3% pure gold in its formulation. Plumb gold solders provide the best color match and retain the overall karat value of the piece of jewelry. “Repair solders” are usually not at karat value. The only time to use a repair solder is when doing repair work such as prong repair or sizing. Do not use repair solder for fabrication because it will decrease the karat value of the piece below the legal standard.

**Annealing**

Annealing gold alloys follows the same basic process as annealing sterling silver.

**Torch Annealing**

Flux becomes completely molten and flows around 1100°F (593°C); this temperature is just short of the annealing temperature for most gold alloys and can be used as a visual indicator. Annealing by torch is best to do in dim light so you can see the heat color of the metal.

**Yellow and Red Alloys:** Annealing temperature is 1100°F (593°C); heat to a dark red.

White Alloys: Annealing temperature is much higher than that of yellow and red alloys—around 1400°F (760°C). Heat to a cherry red and hold for several minutes.
Kiln Annealing
Annealing can also be done in an electric kiln, such as the type used for enameling and metal clay. Using a kiln will anneal the alloy more evenly than is possible with a torch.

Cover the alloy in a barrier flux. If it is wire, make a coil. Wrap it in stainless steel (not aluminum) foil. Add a couple pinches of activated carbon to the packet before sealing it.

Yellow and Red Alloys: Heat the packet at 1150°F (621°C) for approximately 30 minutes

White Alloys: Heat the packet at 1350°F (732°C) for approximately 30 minutes.
The exact time needed will depend on the mass of the metal. The more mass, the more of a heat sink the piece will be and the longer the process will take.

Quenching
When to quench after soldering or annealing will depend on the alloy you are working with.

Yellow Alloys: Quench at black heat, which means as soon as the metal loses the color of annealing temperature.

Red Alloys: Quench at red heat. If red gold alloys are left to air cool, they become brittle and hard.

Nickel White Alloys: Never quench. Quenching nickel white gold can cause stress fractures, which may not be apparent until the piece is formed or finished. Quickly air cool these alloys by setting the annealed or soldered piece on a heat sink, such as an anvil, or using a fan to circulate cool air around the piece.

Palladium White Alloys: Whether to quench palladium white gold depends on the alloy composition. Check with the manufacturer before quenching.

Fabricating
Most gold alloys can be shaped into designs that are as complex as those that can be created in silver. High-karat gold can be shaped into even more complex designs because of its greater ductility. 22K gold most closely resembles the working characteristics of sterling silver.

Lower karat gold alloys (such as 14K and 10K) are harder to form than sterling silver and will work-harden more quickly. However, because of their increased hardness and tensile strength, it is possible to work them in thinner gauges of metal, which will offset the working difficulty.

Nickel white gold alloys are very hard and work-harden very quickly. They are difficult to work by hand; palladium white gold is a better choice for hand fabrication.

Red gold alloys are also harder and more difficult to work with by hand. They are prone to cracking if worked too far, a problem that nickel white gold shares as well. The best alloys for fabrication are yellow gold alloys of 14K and above.
Casting
Different karat alloys and different formulations within the same karat value can have significantly different melting temperatures, casting temperatures and flask temperatures. Suppliers will provide specification sheets outlining these for each alloy.

Many alloys are formulated for specific uses. These include working alloys, open-system alloys, closed-system alloys and universal alloys. Working alloys are used to cast ingots that will be made into sheet or wire for fabrication. Closed-system alloys are for use in a casting machine that has a closed melting chamber with a cover gas such as nitrogen, which greatly reduces oxide formation. Open-system alloys are designed to be used when the metal is melted with a torch in an open crucible.

The differences between gold grain alloys are not confined to temperature alone. A design might cast beautifully in a 14K yellow alloy, but the details may not fill completely when that same design is cast in a white gold alloy because white gold has a different viscosity. Experimentation and meticulous record keeping is a must to be successful when casting multiple gold alloys.

Stone Setting
In general, yellow alloys that are 14K and above are the best for setting stones, though there are some exceptions.

22K gold is rather soft for prong settings but works beautifully for bezel settings, especially around softer stones and enamel cabochons.

In white gold, palladium alloys are the best choice. Nickel alloys are very hard and springy, so great care should be taken to ensure that the prongs are in contact with the stone and stay in contact with it; they have a tendency to spring up slightly, causing the stone to become loose in the setting. Nickel white gold prongs are also not very forgiving—if you have to lift a prong to remove a stone, use care; they tend to easily break.

The great thing about any gold setting is its strength when compared to sterling. Done right, a gold setting can last for decades and protect a valuable stone from loss.

Polishing, Finishing and Patinas
In general, gold can be finished and polished just like sterling silver.

It responds better to mechanical polishing because of its increased hardness, and it will take less effort to bring up a high polish on it. The increased hardness of gold is also a plus when you use mass-finishing methods.

Because gold alloys resist oxidation better than sterling silver, they do not lend themselves well to patination. For an oxidized effect, you can copper-plate the piece. To do this, place the piece in a pickle pot and add a bit of steel wool or wound up steel wire. This will cause
the copper in the pickle solution to plate the piece. You can then patina the piece with liver of sulfur; remove the plating and the patina from the high spots to reveal the gold underneath.

**Scrap Collection and Refining**

Gold is one of the most expensive materials you can work with. If you’re considering adding it to your bench, it is important to formulate a process for capturing and recycling precious metal scrap. The first step in this process is keeping your metals separated.

Carefully separated metals will generate better returns when you send them to a refiner. Separating your metals will also result in clean scrap, which can be melted down, turned into an ingot, and rolled into new sheet or wire; this will save you money in the long run.

If you are working with multiple alloys, have a clearly labeled container for each. Clean your catch pan, bench top and bench pin, as well as any other holding devices, each time you move from one metal to another. You’ll be amazed at what can get caught in a bench pin.

**Hallmarking**

“Hallmarking” refers to the practice of stamping jewelry with a quality mark that informs the customer of the purity of precious metal in a jewelry item. Contrary to popular belief, you are not required to quality mark your jewelry in the United States. But doesn’t mean you shouldn’t, especially if you are working in gold. If you do stamp your pieces with a quality mark, you must also stamp your federally registered trademark or name next to it. This ensures that you are responsible for the precious metal content of the jewelry piece.

More information on the requirements of the National Gold and Silver Stamp Act can be found in the Federal Trade Commission’s Guides for the Jewelry, Precious Metals, and Pewter Industries.

Have a question about working with gold at the bench? Stuck on a technique you can’t work through? Give our Jewelry Tech Team a call at 800.545.6566. They’d love to help you figure it out.

**Sources and Additional Resources**

