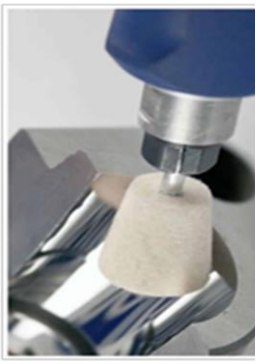
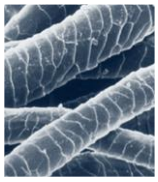
POLISHING: FELT SELECTION AND USE GUIDELINES



Polishing ("mechanical polishing" or MP[1]) should be thought of in terms of very, very fine grinding that is engineered by choice of abrasive and technique to remove less and less material progressively from the surface of a product. Essentially, polishing reduces the roughness of a surface making it reflective – a shiny or "mirror" finish. A polishing felt or fabric is merely a compound carrier, a "media". Standard practice is to use an *abrasive compound* with the media, and to use a technique (force and motion) such that the *abrasive does the work*. There are many varieties of compounds available to choose from with different abrasive types and grits, plus lubricants and waxes. The use of compounds can be messy, however, as compound will sling off a tool during polishing. Spartan Felt has developed *abrasive impregnation* which fixes abrasive in the tool used; this technology often can eliminate the use of additional compound and the related mess.

The way in which the compound is delivered to the surface being polished plays a significant role in the results achieved. The hardness of the felt, surface speed, pressure applied, and contact area with the surface being polished all contribute to the amount of surface removal (aka "polishing") desired. In the polishing or finishing genre, the terms *"cutting down"* and *"color buffing (or coloring)"* indicate differing levels of surface removal. Whether referred to as "buffing", "polishing", or "finishing", generally it is the same *two-step process, "cutting", in which a desired amount of a surface is removed,* then *"coloring", bringing luster, brightness, and reflectiveness to the surface*.



Wool, natural abrasive scales

WOOL felt is the most commonly used media in polishing. The scales on wool fiber will interlock in the making of felt, making it extremely durable, and the scales themselves are abrasive. Wool however, must be kept cool while polishing because it is an insulator, and will internalize heat until it burns from the inside.

SYNTHETIC fiber used in polishing is usually polyester or nylon. Synthetic fiber "felt" is typically a non-woven and may have binder to create the hardness desired. Hard forms of synthetic media can *cut* very well with the appropriate abrasive compound or impregnation. Soft versions of synthetic fiber media are generally not durable, and so wool is generally a better choice for coloring[2].

Important Parameters for Polishing-

- Abrasive Choice
- Mechanical Force (Torque) applied to work the abrasive against the surface.
    - Hardness of Media (Bob, Wheel, Pad)
    - Pressure Applied
    - Motion of media (in terms of surface speed)
- Temperature Control (avoid overheating issues)

Cutting		Coloring
Hard <	----------(*Media*)---------- >	Soft
Slow <	----------(*Surface Speed*)--------- >	Fast
Firm <	----------(*Pressure*) ---------- >	Light
Slow <	----------(*Feed Rate*)---------- >	Fast
Aggressive <	---------(*Abrasive*)---------- >	Fine

In general, "cutting" involves a hard media with an aggressive abrasive, held under firm pressure to the surface at a low surface speed and feed rate. "Coloring" is typically done in fast, light touches with a soft media and fine abrasive.

[1] Other methods include electro-polishing, material is removal electronically. Electro-plating involves depositing material over a surface.

[2] Wool is an animal-derived material, and FDA regulated applications may restrict materials with animal-derived ingredients. Animal-derived ingredient free (ADI-free) polishing medias are offered in these cases.

HOW TO CHOOSE A FELT HARDNESS FOR AN APPLICATION

As an abrasive carrier, a felt bob or wheel delivers abrasive grit to a surface in degrees of aggressiveness based on the parameters cited previously. The surface hardness of the felt is a critical factor in the level of aggressiveness. Hard felt holds the abrasive out against the surface being polished, and softer wool will allow abrasive to penetrate it.

- ✓ ***General Rule: The harder the felt, the more aggressive the cutting capability.***

Hard surfaces generally require a hard felt for the cutting step. But a soft metal might be badly scratched by a hard felt. The hardness of the surface being polished typically determines the hardness of the felt that can be used, so the level of hardness chosen is generally *application specific.* In the example, gold is softer than stainless steel, therefore one would expect to use a softer felt and a finer grit compound when coloring gold as opposed to stainless steel.

- ✓ **A hard felt is more efficient in cutting a hard metal, and a medium hardness felt may be best for coloring.**
- ✓ **For soft metals, to cut without damage, a medium hardness may be the limit, and a soft felt used in coloring.**

Recall the selection of cutting compound is key to the application because *the abrasive does the work*. In general, a fine compound grade is used with a soft felt, and coarse compounds with hard felt.

Note that polishing is known to be an artisan activity meaning that skilled operators develop individual approaches and techniques. Therefore, one might use a "medium" felt while another uses a "hard" felt and both achieve the same result. So, individual techniques and experience play a significant role in polishing results as well.

Note also that the term "density" is often used interchangably with "hardness" in describing polishing felt. Density is defined as "mass per unit volume" and is not a measurement of hardness. However, felt is often hardened by compression, in fact making it more dense, so the terms have been used synonimously in the industry.

Spartan Felt Hardness's

- Soft – Coloring soft metals (gold, copper, aluminum)
- Medium – Coloring Steel, Bronze, Brass; Cutting soft metals.
- Hard – Cutting of Steel & harder metals.
- Rock Hard
- Flint Hard
- Diamond Hard

Specialties

Example of Metal Hardness	Hardness (Rockwell B)
Aluminum (H14)	20-25
Aluminum (H34)	35-40
Copper	10
Bronze (Jewelry)	47
Brass (Red)	65
Brass (Yellow)	55
Nickel Silver	60
Steel (Low Carbon)	60
Stainless Steel (304)	88
Stainless Steel (316)	95
Titanium	80

Common Compounds & Uses

Black Emory- Coarse, for hard metals.

White "Diamond" – Remove scratches from soft metals; luster on hard metals.

Brown Tripoli- Remove scratches from Al & SS, provides high luster most soft metals

Green- provides luster on hard metals.

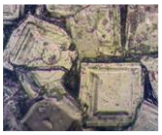
Red Rouge- high luster on hard metals.

Blue All-Purpose- soft metals and plastics.

ABRASIVE IMPREGNATION

Spartan offers impregnation of abrasives into media as an option to reduce or eliminate the use of compounds. Water-based chemistries lock the abrasive into the felt. As the polishing tool wears, fresh abrasive is available to continue the polishing work.

- **Using abrasive impregnated tools without compound is a cleaner polishing process.**
- **Automation is easier to implement because steps to add compound are not necessary.**
- **The ability to impregnate various abrasives & chemistries allows complete customization to suit the application.**



Aluminum Oxide
Shears into finer particles. Wide range in grits; soft metals to stainless steel.

Silicon Carbide
Cuts hard metals fast but breaks down quickly.

Diamond
Cuts the hardest metals such as titanium, does not break down, longer tool life.

SHAPING POLISHING TOOLS TO MATCH PROFILES

A key concept to improving the efficiency of polishing is to increase the contact area of the abrasive and felt against the surface being polished. For example, a ½" wide wheel in theory should be able to polish a surface twice as fast as a 1/4" wide wheel, given that all other variables are the same. If a surface has a profile to be polished, then shaping a tool to fit that profile is going to increase the contact area, and efficiency and accuracy is improved.

Spartan routinely shapes tools to deliver more efficiency with precision in polishing applications. These tools are often also impregnated with abrasive.

Standard shapes include cones, domes, spheres, and tapers (see our website or catalog).

Tools are shaped to match the profile of a valve sealing disk to polish the seat

SURFACE SPEED RECOMMENDATIONS FOR FELT BOBS & WHEELS

One of the critical factors related to cutting and coloring is the *surface feet per minute (SFPM)* of the felt tool (i.e., bob, wheel, cone, etc.) at the contact point of abrasive to the substrate being polished.

Suggested Speeds for Cutting & Coloring (in Surface Feet Per Minute):

	CUTTING SFPM	COLORING SFPM
ALUMINUM AND OTHER METALS	6,000 TO 8,000	6,000 TO 7,000
BRASS	6,000 TO 9,000	6,000 TO 8,000
CARBON STEEL	7,000 TO 9,000	7,000 TO 9,000
STAINLESS STEEL	8,000 TO 10,000	7,000 TO 9,000

The formula for calculating surface feet per minute (SPFM) is the circumference of the bob or wheel divided by 12, times the speed of the arbor: (π X DIAMETER)/12 X ARBOR SPEED = S.F.P.M. Tables of surface speeds for some popular diameter sizes and shaft speeds are provided below.

WHEELS	**Wheel Diameter/ Surface Speed (SFPM)**					
RPM Arbor	**4"**	**6"**	**8"**	**10"**	**12"**	**16"**
800	838	1257	1676	2094	2513	3351
900	942	1414	1885	2356	2827	3770
1000	1047	1571	2094	2618	3142	4189
1200	1257	1885	2513	3142	3770	5027
1400	1466	2199	2932	3665	4398	5864
1600	1676	2513	3351	4189	5027	6702
1800	1885	2827	3770	4712	5655	7540
3600	3770	5655	7540	9425	11310	15080

BOBS	**Bob Diameter/ Surface Speed (SFPM)**					
RPM Arbor	**¼"**	**½"**	**¾"**	**1"**	**2"**	**3"**
5000	327	655	982	1309	2618	3927
10000	655	1309	1964	2618	5236	7854
15000	982	1964	2945	3927	7854	11781
20000	1309	2618	3927	5236	70472	15708
25000	1636	3273	4909	6545	1309	19635
30000	1964	3927	5891	7854	15708	23562

One can from the above charts that bobs do not reach the recommended SPFM for metal examples listed. Note, these recommendations were set using wheels. For bobs, additional pressure is routinely applied, and this improves the polishing performance such that bobs function very well under lower SPFMs.

APPLICATION RECOMMENDATIONS:

Material	Cutting	Coloring
Acrylic or other plastic particularly for clear or see-through applications	Soft wool felt (or synthetic) with pumice in slurry form.	Soft-extra soft wool felt (or synthetic) w/cerium oxide or aluminum oxide slurry
Aluminum die casting or sand casting	Hard wool felt or rock hard with tripoli	Medium wool felt with white rouge
Brass or bronze castings or stampings	Medium wool felt with tripoli	Medium wool felt with red rouge
Chrome, automotive restoration & customization	Hard to rock hard wool felt with tripoli	Medium to hard wool felt with green chrome rouge
Copper casting or stampings	Medium wool felt with tripoli	Medium or soft wool felt with red rouge
Glass, i.e. polishing bevels for mirrors, crystal, etc.	Hard or rock hard wool felt or synthetic substitute w/fast cutting cerium oxide slurry or pumice	Medium density wool felt or synthetic substitute, cerium oxide slurry
Gold and other precious metals[1]	Medium wool felt with an extra-fine, dry tripoli	Medium wool felt with a red rouge
Granite	Soft wool felt or synthetic with tin oxide paste or slurry	
Marble	Extra soft wool felt or synthetic	
Stainless steel or steel on inside diameters for inlets or valves, or specialty dies	Hard wool felt with stainless steel cutting compound.	Medium to extra soft wool felt with stainless steel coloring compound fine diamond compound, or white rouge
Titanium alloys	Hard to flint hard wool felt with various diamond compounds	Hard wool felt with finer diamond compounds

[1] Note: Some ring manufacturers use high density felts with a silicon carbide compound for cutting purposes. However, the recommendation above is for polishing/buffing only.

MISCELLANEOUS

Felt Wheels used with Abrasive Belts:

A "Contact Wheel" is the wheel over which an abrasive belt runs. Wool felt contact wheels have an even, level face, and are available in varying degrees of hardness, from "extra soft" to "rock hard," depending upon the desired flexibility when polishing against the abrasive belt. While the felt wheel is costly in terms of dollars, its uniformity of wear and shape retention engenders a lengthy production life. A wool felt wheel may also be contoured or grooved.

Set-up (abrasive) Wheel:

"Set up" wheels (sometimes referred to as polishing wheels) are essentially carriers of permanently (glued) fixed abrasive grain. A wheel's face thickness is surface coated with glue and abrasive is then cemented onto the wheel. A hard wool felt wheel is typically used with a #180 or #220 emery cake.

Contact us for more information on the selection of polishing tools.