ZAHNER®

METAL GUIDE & TOOLKIT

METAL CHARACTERISTICS

- Metal Hardness
- Metal Reflectivity
- Metal Thickness
- Relative Costs of Metals
- Metal Density
- Thermal Movement

METAL MAINTENANCE

- Metal Aging
- Cleaning Contaminants
- Interior Stainless Steel Cleaning
- Maintaining Stainless Steel

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METAL HARDNESS

Metal hardness is a characteristic that determines the surface wear and abrasive resistance. The ability of a material to resist denting from impact is related to hardness as well as a material's ductility. Various degrees of hardness may be achieved in many metals by tempering, a heat treatment process used in cold rolled and cold worked metals. As the grain structure of the metal undergoes cold forming, the grains are stretched and altered. The surface becomes harder, resisting deformation from contact. Tempering heats the worked metal to temperatures at which the grains begin to dissolve. There are series of standard tempers available. These tempers and their availability in a particular alloy vary, depending on the nature of the grains as they recrystallize. The temper designation is actually determined by this grain size, rather than the yield strength of the metal.

METAL HARDNESS CHART

The below chart is useful for determining which metals will be impervious to scratching and dinging, as it relates to the Rockwell scale and ductility. The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload.

Metal	Alloy & Temper	Hardness Rockwell B-Scale	Yield Strength (KSI)	Yield Strength (MPa)	Ductility Degree 1. Very Ductile 5: Stiff
Aluminum	A93003-H14	20 to 25	21	145	1
Aluminum	A93003-H34	35 to 40	29	200	1
Aluminum	A93003-H14	20 to 25	20	138	1
Aluminum	A96061-T6	60	40	275	4
Copper	1/8 hard (cold roll)	10	28	193	1
Gliding Metal	1/4 hard	32	32	221	1
Commercial Bronze	1/4 hard	42	35	241	2
Jewelry Bronze	1/4 hard	47	37	255	2
Red Brass	1/4 hard	65	49	338	2
Cartridge Brass	1/4 hard	55	40	276	1
Yellow Brass	1/4 hard	55	40	276	2
Muntz Metal	1/8 hard	55	35	241	3
Architectural Bronze	As Extruded	65	20	138	4
Phosphor Bronze	1/2 hard	78	55	379	3
Silicon Bronze	1/4 hard	75	35	241	3
Aluminum Bronze	As Cast	77	27	186	5
Nickel Silver	1/8 hard	60	35	241	3
Steel (Low Carbon)	Cold-rolled	60	25	170	2
Cast Iron	As Cast	86	50	344	5
Stainless Steel - 304	Temper Pass	88	30	207	2
Lead	Sheet Lead	5	0.81	5	1
Monel	Temper Pass	60	27	172	3
Zinc-Cu Tn Alloy	Rolled	40	14	97	1
Titanium	Annealed	80	37	255	3

INCREASING METAL HARDNESS

There are a number of ways to harden architectural metal, through the mill, or during the fabrication process. Each of the hardening mechanisms are introducing crystal lattice irregularities into the metal crystal structure, causing dislocation of the metal's structure to become more difficult. The result is a harder, less ductile metal surface.

Work hardening refers to the straining or cold-hardening of a metal surface. As metal is bent or strained repeated, the plasticity of the metal reduces, becoming work-hardened and less ductile. Usually refers to strain-hardening behavior of the metal as it is worked at room temperature. Certain metals alloys such as nickel-titanium do not undergo strain hardening but actually has a characteristic of strain relieving as it returns to the original shape.

Solid Solution Strengthening refers to a metal in the alloying process, in which an alloying constituent is inserted into a solid material. One or more elemental constituents are able to enter into a heated but solid solution. The metal is then rapidly quenched to capture the element in solid solution.

Age hardening is a process which occurs rapidly in the first few days after casting, then much slower over the next several weeks. This process is often referred to as "natural age-hardening". Another artificial version of this process can be used by heating the metal for a short period of time at a high temperature. The result is that it will stabilize the properties, further strengthening the alloy. This process is known as "artificial age-hardening," or precipitation hardening.

Anodization, a process specific to aluminum, has a hardening effect. The final step in creating anodized aluminum is to harden and seal the surface by use of deionized boiling water or metal salt sealers. Sealing is required to close the pores of the oxide film and provide uniformity to the exception of the alloying constituents.

Case hardening refers to a surface heat treatment process used to produce a hard, wear-resistant surface on metal. Methods of case-hardening include carburization, cyaniding, nitriding, flame hardening, and electroinduction hardening.

Tempering is a heat treatment process used in cold rolled and cold worked metals. As the grain structure of a metal undergoes cold forming, the grains are stretched and altered. The surface becomes harder, resisting deformation from contact. Tempering heats the cold worked metal to temperatures at which the grains begin to dissolve into one another. There are series of standard tempers available. These tempers and their availability in a particular alloy vary, depending on the nature of the grains as they recrystallize. The temper designation is actually determined by this grain size, rather than the yield strength of the metal.

Back-blasting a metal surface is a way of flattening metal, which also tends to greatly increases the surface hardness. It is advised to back-blast a material after forming operations, because the material will become harder to work and form after blasting the surface.

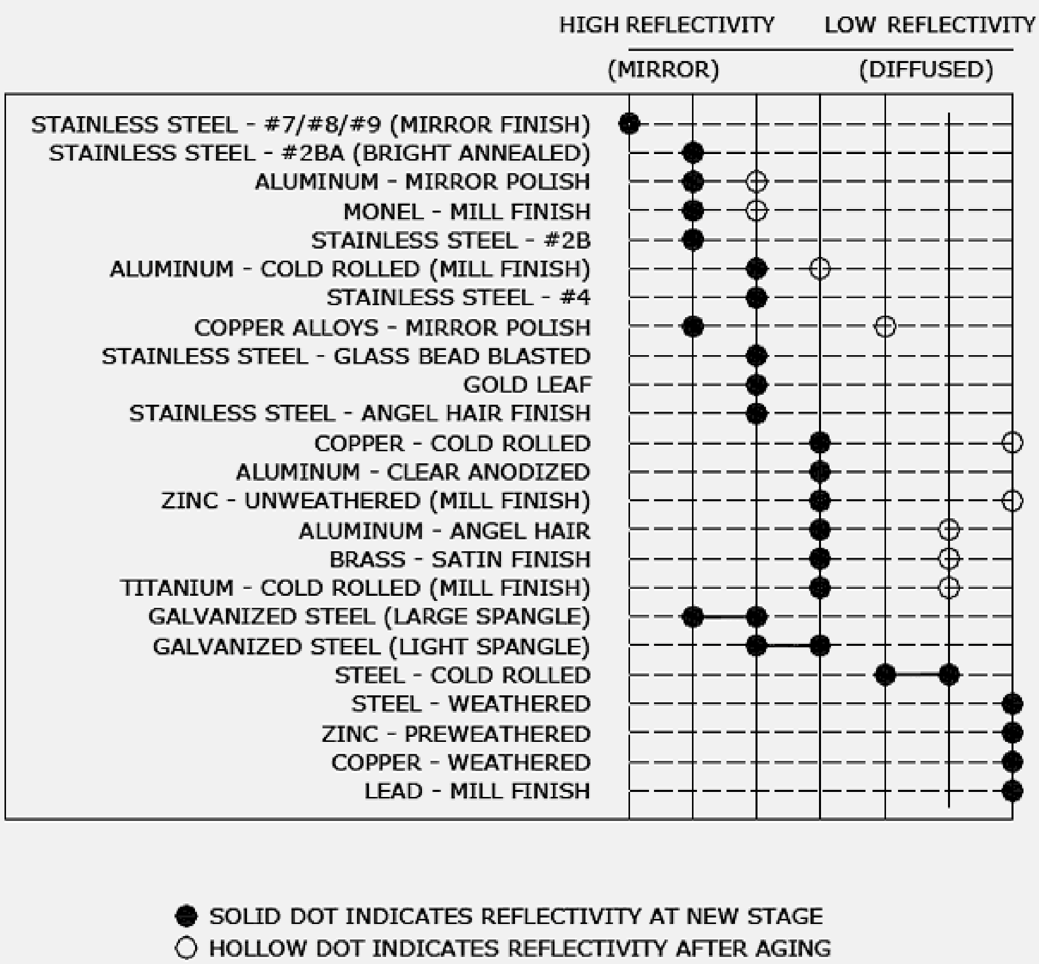
METAL REFLECTIVITY

With metals, it is often desired to have a reflective surface-not necessarily blindingly bright but one that catches the eye. Its relative reflectivity is much greater than surrounding surfaces. A gold leaf surface shimmers in the sunlight like a beacon when seen from a distance. It is as if the light is generated from the metal itself. Even on an overcast day, gold will appear remarkably bright. A zinc surface by contrast, dulled by oxide, reflects a blue-gray tone in bright light and looks the color of pewter in overcast sky.

The reflective nature of the surface of metals can be adjusted through the use of various processes. This is true of all metals. However, over time certain metals may change in reflectivity as the metals oxidize.

For this reason, some surfaces are limited in their choices. However, if desired, you can achieve a dull, flat, black appearance, devoid of the slightest visual sheen of any kind. Blackened by oxide, copper, zinc, and aluminum can have grainy, black, mottled surfaces. The mottling has degrees of black, some with a reddish tint, others with a gray tint.

RELATIVE REFLECTIVITY OF VARIOUS METALS



METAL THICKNESS

Metals are measured in varying units. This seemingly strange set of measurements is in part due to history of each metal.

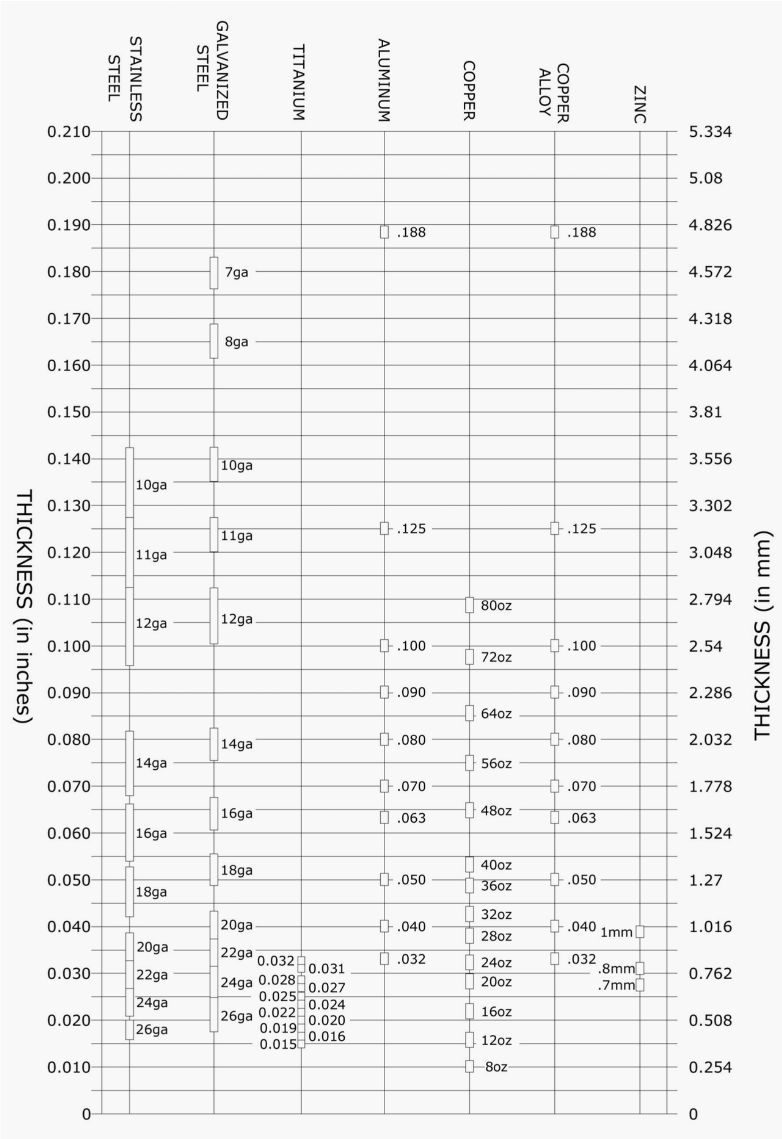
The steels (and stainless steels) are measured in gauge, and correspond with a decimal inch thickness. The higher the gauge number, the thinner the sheet. 16ga (gauge) is roughly 1/16 inch, which is a nice thing to remember if you remember nothing else about sheet metal gauge.

Galvanized steel, which has a thin layer of zinc on steel sheet, also uses the gauge system. Because of its thin coating, it slightly thicker when converted into inches than uncoated steels.

Aluminum is measured by the more familiar decimal relationship. Copper is another story altogether. Copper is measured in ounces per square foot, which continues to this day in part due to copper's use in computer transistors, the smallest of measurements. 1oz copper is equal to 1.37 mils, or thousands of an inch. For architectural use, 48oz copper is close to 16 ga stainless steel, to put things in perspective.

Mastering the world of architectural metals might seem like traveling across the different countries of Europe. Each material has its own language, and understanding them can take time.

The aluminum and copper industries are as different from each other as they are from the steels. Monel, titanium, zinc, for example, address their own industries with a jargon created from a mixture of the others. This leads to confusion for those using the materials. You must translate your understanding from ounces per square foot to decimals or gauge numbers, depending on your familiarity. Adjacent is a simple chart which should help when comparing standard sheet metal thicknesses between various metals.



METAL COSTS

A relative cost comparison of metals can be made between materials, but it should come with a number of caveats.

First and foremost, it is important to note that metal prices are always changing. Metals are commodities, and are traded as such. Their value rises and falls with demand, and as global markets dictate. The more common metals such as aluminum, are fairly predictable. Aluminum is the third-most abundant element, after oxygen and silicon. As such, it rises and falls with the cost of electricity. A rare metal such as gold, on the other hand, is far more volatile.

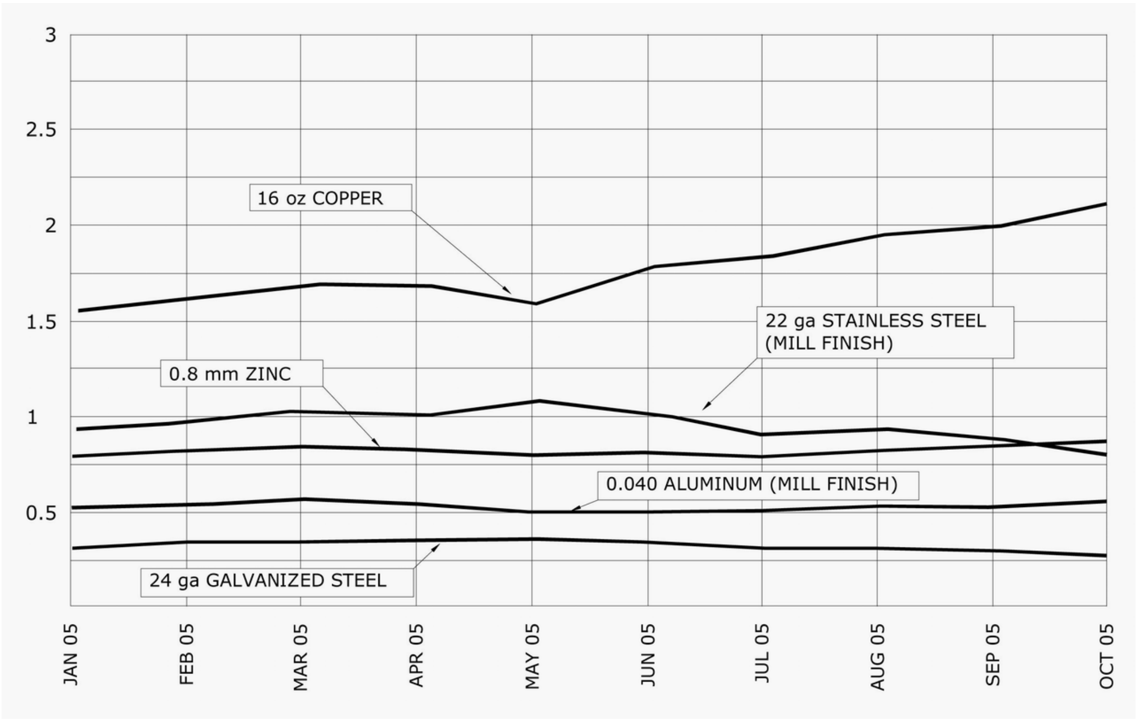
The second aspect to consider, is a material's lifecycle cost. Quality materials used in architectural systems will typically have a higher upfront costs. Many of the less expensive options have a short life expectancy, costing more over time.

Third, and last: it is better to measure the installed material than the base material. For most metals, the fabrication and installation cost will be the same. So a metal like copper, which is that is two or three times more expensive than steel sheet, might only be 2% more expensive when installed. This is the illusion of cost per square foot when discussing raw materials.

Below, a chart shows a degree of volatility even in the span of less than a year, this is an older chart, which similar thickness of copper, zinc, aluminum, galvanized steel, and stainless steel sheet prices per square foot.

Note that these figures may be direct from the mill without secondary finishes applied. Commercial quality standards are rarely to the levels needed for good architectural or ornamental work. Moreover, one mill's commercial quality may be another mill's architectural quality; therefore it is always advisable to acquire metal samples that represent the quality a mill can provide.

Comparative costs do not usually account for the maintenance, long-term performance, or weathering characteristics of the metal. These factors, as well as others, must be included to arrive at a true, albeit subjective, conclusion as to which metal is best suited for a particular surface. For an up-to-date pricing on these materials, contact Zahner.



METAL DENSITY

Density is a concept to consider in addition to a metal's weight and hardness. Every material has a particular feel to it, a weight and a surface resistance. This feel is partially characterized by the density of the material.

Density can be measured by its mass per volume, but it can also be understood in more familiar terms by understanding a material's specific gravity. Specific gravity is the ratio of a material's density with that of water. It is a relative (unitless) measure of the weight of a material. For example, gold has a specific gravity of 19.32, so if you took a cubic meter of gold, it would weigh 19.32 times as much as a cubic meter of water.

METAL DENSITY CHART

The chart below describes the various specific gravities of architectural metals, which range from the lightness of titanium and aluminum to the heavy density of lead and gold metals. Magnesium and silver, though not necessarily architectural metals, are indicated for relational comparison.

Another way to understand specific gravity is how it relates to other materials. Plastics have a very low specific gravity, hovering around 0.9 to 1.5. When you pick up a piece of plastic it feels light and has a cheapness to it. Plastic materials can be formed and painted to look like metal, but they will always feel hollow. What you're feeling is the material's density, its specific gravity.

With the exception of aluminum, most architectural metals are very dense. They have a very high specific gravity. Metals typically have a dense crystal structure. The atoms which make up the material are aligned in a very dense pattern. You can feel that sense of density to the touch. If you tap the material, you can hear the metal resonate. This is because of its dense and hard atomic structure. This is what makes metal sound like metal.

Metal	Density (lb/in 3)	Specific Gravity
Magnesium	0.064	1.77
Aluminum	0.098	2.7
Titanium	0.161	4.51
Chromium	0.25	6.92
Zinc	0.258	7.14
Tin	0.264	7.3
Stainless Steel (Type 410)	0.278	7.7
Iron / Steel	0.284	7.87
Stainless Steel (Type 304)	0.285	7.9
Muntz Metal	0.303	8.39
Cartridge Brass	0.308	8.53
Commercial Bronze	0.318	8.8
Monel	0.319	8.83
Nickel	0.321	8.9
Nickel Silver	0.323	8.95
Copper	0.323	8.96
Silver	0.379	10.49
Lead	0.409	11.34
Gold	0.687	19.32

THERMAL MOVEMENT

Thermal movement in architecture is the expansion and contraction of materials at an atomic level, based on temperature. In short, metal surfaces expand when the temperature rises. When the temperature dips, metal surfaces contract.

Thermal movement is one of several important aspects to understand when creating any architectural system. When designing a metal facade or roof, thermal movement ranks up there with joinery methods, constructibility, water shedding, and the behavior of light on the surface. These are some of the primary constraints for designing any large architectural system.

THERMAL MOVEMENT ANALYSIS OF METAL FABRICATIONS

Using this chart, you can easily determine how various metal systems will perform and what kind of tolerance your design should employ.

For instance, a length of metal, 120 inches (roughly 3 meters), when installed outdoors can experience a temperature differential of as much as 100°F (38°C). When this occurs, the metal will increase in length the amount indicated for that metal. If the metal is to be subjected to a higher temperature range, then you must allow for the additional expansion.

Metal	Coefficient of Thermal Expansion u in./in. C	Expected Expansion of a 120 inch sheet* (in)	Expected Expansion of a 3 meter sheet* (mm)
3003 Aluminum	23.2	0.11	2.79
5005 Aluminum	23.8	0.11	2.79
6063 Aluminum	23.4	0.11	2.79
Copper	16.8	0.08	2.03
Gliding Metal	18.1	0.08	2.03
Commercial Bronze	18.4	0.08	2.03
Jewelry Bronze	18.6	0.08	2.03
Red Brass	18.7	0.09	2.29
Cartridge Brass	19.9	0.09	2.29
Yellow Brass	20.3	0.09	2.29
Muntz Metal	20.8	0.09	2.29
Architectural Bronze	20.9	0.10	2.54
Phosphor Bronze	18.2	0.08	2.03
Silicon Bronze	18.0	0.08	2.03
Aluminum Bronze	16.8	0.08	2.03
Nickel Silver	16.2	0.07	1.78
Iron	11.7	0.05	1.27
Steel	11.7	0.05	1.27
Cast Iron	10.5	0.05	1.27
304 Stainless Steel	16.5	0.08	2.03
Lead	29.3	0.13	3.30
Monel	14.0	0.06	1.52
Tin	23.0	0.10	2.54
Zinc - rolled	32.5	0.15	3.81
Zinc - Cu, Tn Alloy	24.9 with grain	0.11	2.79
Zinc - Cu, Tn Alloy	19.4 across grain	0.09	2.29
Titanium	8.4	0.04	1.02
Gold	14.2	0.05	1.27

DIAMOND PATTERNS: THERMAL MOVEMENT

In standard facade designs, the diamond pattern is inherently strong. By using interlocking plates of the surrounding panels, the load is taken out at the seam. Correctly installed, diamond pattern systems have shown centuries of performance due to the inherent strength and the reduction of stress maintained by the overlapping pattern.

Dimensional changes of the panel elements caused by thermal effects are handled efficiently with the diamond pattern. The top edges of each panel are fixed, usually with clips; and the bottom edges interlock into the single-lock seam along the top edge of the row of panels below. Expansion and contraction are away and toward the clips, effectively sliding over the single lock of the panel element below.

Thermal movement is one of the big considerations in developing a metal panel system which lays flat and doesn't buckle or oil can. Other considerations include metal thickness (and thus its tendency to bend or bow), reflectivity (highly reflective surfaces reveal more discrepancies in flatness), and wind forces.

Each of these issues can be resolved through careful planning and proper detailing. Learn more about how to develop a high-quality metal system by contacting an expert at Zahner.

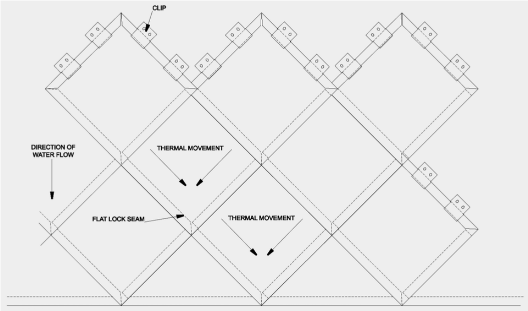
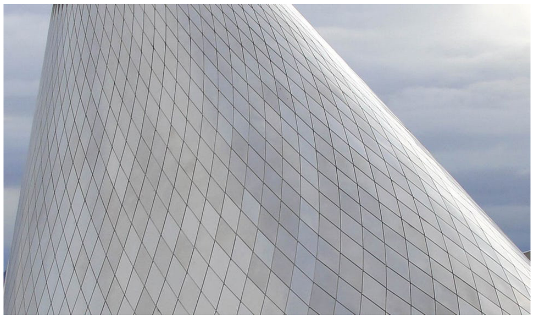


DIAGRAM OF A TYPICAL DIAMOND-PATTERN FLAT-LOCK SEAM METAL SYSTEM.



TACOMA MUSEUM OF GLASS USES A CUSTOM DIAMOND-PATTERN SYSTEM.

METAL AGING

Many of the basic construction metals physically transform over time. As natural environmental conditions interact with the metal its surface changes in texture and color. Initially, a basic oxide layer is formed. It doesn't take too long for the the oxide layer to convert to a hydroxide. Soon after, the hydroxide layer begins to combine with other elements in the atmosphere. In the end, the surface of the metal has a stable mineral composition that is very resistant to further alteration. This aging process is apparent in natural aluminum, copper and the copper alloys, lead, steel and zinc.

Zahner engineers have created a range of surfaces which enhance the weathering process to bring the metal surface to a texture and color desired by clients. For interior applications, these patinated surfaces can be locked-in by using inhibitors that will essentially freeze the texture and color at a particular state of patina.

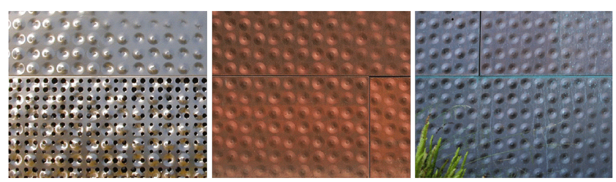
Exterior applications are more complex, because the combined heat, moisture and pollution cause the metal surfaces to continue to change. Certain measures can be taken to delay this transition, and certain patinated surfaces are more resilient than others.

Adjacent is the patination of the metal surface apparent on the de Young Museum, a project that Zahner completed in 2005. The architects originally desired a light golden-hued appearance for the museum, but this intent evolved as the conversation evolved, and the design team desired the museum to blend and emerge from it's forested surroundings like an ancient indigenous structure.

Zahner helped guide this decision. A champion of the integrity, resilience, and evolution of copper, we asked the clients for a little faith in the material, explaining that over time it would transition from it's bright golden red, to a dark brown, to a black, and finally, it will slowly emerge into earthy greens.

Other exterior installed metals, such as zinc and steel patinas maintain their color over time, darkening subtly or lightening in some cases based on the weather, pollution, and proximity to water.

The results are far from a static painted appearance; Zahner finishes tend to reflect the natural beauty of the metal and its surrounding elements. Paint yellows, cracks, peels, and scratches quite easily. Natural metal surfaces age in a more sophisticated ways, growing and deepening in intensity.



STAINLESS STEEL VERSUS ALUMINUM

These two metals are somewhat similar in appearance, but they could not be further apart in the way that they perform over time. Stainless steel is a stunning material for its ability to maintain its appearance over decades, while aluminum performs well structurally, but as a finished surface, it is less than desirable.

Aluminum has a tendency scratch easily, and it whitens over time. The surface of aluminum will become murky as the rain and sun beat down on it. Therefore Zahner rarely uses this material as a finished surface, instead using the material for its structural properties.

FINGERPRINTS ON METAL

Like glass, reflective metal surfaces are prone to fingerprinting. Like glass, these surfaces can be cleaned. The oils from people's hands can become impregnated in the surfaces of the metal, but with the right cleaner, many of these surfaces can be cleaned.

Typically, if a surfaces is going to be in a highly trafficked area, we recommend a preweathered surface such as pre-weathered zinc, which is a series of matte surfaces that are less prone to showing fingerprints.

In some cases, that finger prints on metal is actually desirable. For instance, with certain copper materials in heavily trafficked areas will actually brighten the finish as people hands prevent the copper from oxidizing. On metals such as the Dirty Penny patina on copper, the result of oils on the surface increases the iridescent qualities inherent in the metal surface.

CLEANING CONTAMINANTS

There are four major common contaminants, labeled Type A - Type D; some contaminants are more prevalent in certain areas, and certain metals are better at handling some contaminants than others. For instance, stainless steel, a metal known for its strength and resilience, will deteriorate under certain conditions where Aluminum would not, and vice versa.

TYPE A (MILD ADHERENCE)

Type A contaminants such as mild soot, residue from evaporation patterns, and dust from airborne particles can be cleaned from the surface of nearly any metal using hot water and amild detergent. Pressure washing will also aid the cleaning of the metal surface. (Note care in not driving water into the seams between metal panels).

Such cleaning processes can be performed on most lacquered and patinated metal surfaces without harming the protective oxide layers. It is recommended to clean metal surfaces this way at least yearly.

TYPE B (MILD ADHERENCE)

Type B contaminants such as greases and oils caused by fingerprints, adhesives, and hard water spots or scale are more adherent and require something that will dissolve and displace the oils or organic polymers used as binders. Xylene will work on metal surfaces without harming them, as will window cleaners containing vinegar or citrus based, biodegradable cleaners. Note: if a lacquered coating is on the metal, solvents and strong cleaners can damage or remove the lacquer.

There are a variety of cleaners available at local hardware stores that contain various solvents. Some solvents work well on dissolving and displacing hydrocarbon based oils and paints while others work better on acrylic polymer based adhesives. Thoroughly rinse the surface after cleaning. You can follow up with a window cleaner to remove streaking.

TYPE C (STRONG ADHERENCE PARTIAL ETCHING)

Type C contaminants can be daunting. Dirt deposits from silicone joints, bird waste, concrete splatter, plaster remnants, chlorides such as de-icing salts, paint and graffiti can seriously damage a surface, especially if left unmitigated for long periods of time. Removal of these can remove the oxide layer and lacquers if present. Attempt the solution on a small less visible section or sample for the Type A contaminants first. Direct pressure of the washing nozzle to the proximity of the contaminant and see if this removes the particles. If the contaminant is new and has not yet developed molecular bonds with the metal surface it should release. At this point, various techniques for different metal finishes should be considered.

Aluminum: Mild abrasive slurry can be considered. Test an area of the surface first. Scratching anodized surfaces can ruin them so exercise caution. Lacquer thinners or paint removers will not have a detrimental effect on the metal surface.

Copper and Copper Alloys: Any abrasive will remove a portion of the oxide or patina that is present on the surface. This will have to be restored after cleaning. Removal of paints and graffiti using lacquer thinner or other paint remover should have little effect on the copper oxide. Sealants and the oils they exude will brighten the copper surface in the proximity of the seal or where run off waters collect. Compounds emitted from sealants, even years after they are applied, inhibit the natural oxide growth copper and copper alloys are known for. The sealant needs to be removed or sealed over with a paint coating if possible. Otherwise, expect continued brightening.

Stainless Steels: Consider a copper knife or copper scraper to remove adherent particles. Used correctly, the soft copper will not scratch the stainless steel surface. Chlorides are the greatest concerns to stainless steels. These should be removed at the earliest possible time to prevent etching the surface. (cont.)

Titanium: Titanium has an exceptional hardness and thus a copper knife can be used similar to stainless steel. The oxide can be scratched if other abrasives are used. Very few solvents will harm titanium. Salts can be washed from the surface. Zinc: Zinc is a soft metal and its oxide is also very soft. Many substances will stain zinc surfaces as they decay and interact. Salts and bird waste should be removed before they have the opportunity to decay. Mild abrasives can be used. It is suggested that test areas be tried.

Most solvents used to remove paint will not affect the zinc oxide. The trouble is the porosity of the zinc surface holds the paint, making it more difficult to remove.

TYPE D (CHEMICAL ATTACK)

Type D Contaminants are molecular interactions with the ambient. Some examples include rust oxides, sulfides and carbonates, heat tint or discoloration from heat, oxidation, and embedded particles from silica or steel (which can cause surfaces such as stainless steel to appear to rust). The chemical and atomic bonds made are not removable without the removal of some of the surface. For stainless steels that have been attacked by de-icing salts or other halogen salts, the rusting that results can be cleaned with commercial rust removers. Generally, they involve dilute phosphoric acid. After removal, thoroughly rinse the surface. Heat tinting oxides on steel or stainless steels can successfully be removed using phosphoric acid based cleaners. Phosphoric acid based cleaners will dissolve the oxide surface from copper alloys leaving them bright.

Zahner has proprietary processes for cleaning a number of oxides, sulfides and carbonates from metals. Stains such as white staining of zinc or galvanized surfaces, dark red stains on lead or terne surfaces can be removed. Feel free to contact us to discuss your specific requirements.

INTERIOR STAINLESS STEEL CLEANING

All metal finishes are delicate in nature and care needs to be exhibited in the cleaning process. One should use clean cloth or soft sponges to wipe the surfaces. Whenever possible, do not spray or apply cleaning agents directly on the metal surfaces, spray on the cloth. Always use clean, fresh, warm water when starting on new areas. Do not use abrasive pads or steel wool type products.

When cleaning a surface for the first time, test the procedure in an inconspicuous area. If a successful result is obtained, cleaning the rest of the surfaces can begin. Unless all parts of a surface are cleaned equally, there will be a visible difference in the finish. Foreign steel particles being deposited on the surface can be cleaned with a sponge or cloth soaked in a neutral detergent or a mild soap and water solution. Rinse immediately with a clean water rinse.

STEPS FOR CLEANING INTERIOR STAINLESS STEEL WITH AN ANGEL HAIR® FINISH:

The steps outlined on this page can be used on a variety of finishes on stainless steel. The mill provides a number of standard finishes, but Zahner also has developed a finish designed to reduce glare in a non-directional finish. Angel Hair stainless steel is a surface developed by Zahner used for muted reflectivity in interior and exterior applications. When properly installed, it will maintain the same appearance after decades of weathering. The material is easily cleaned with water when natural pollutants and dirt begin to appear on its finish.

INITIAL CLEANING

1. Inspect the surface. If grease, stains or other difficult to remove spots exist, pre- cleaning is required. To pre-clean apply an appropriate solvent to a clean and soft cotton cloth. Cloth should be damp but not dripping. Test in an inconspicuous area first. If a successful result is obtained, cleaning can begin. Gently rub damp rag on stain. Repeat as necessary. Change cloth frequently to ensure that the cloth is damp and clean.

2. Clean the surface. Using a clean and soft cotton cloth gently apply clean soapy warm water to the area of stainless steel. Wipe in a swirl pattern across the stainless steel surface. Rinse to ensure soap residue is removed. Change cloth frequently to ensure that the cloth is damp and clean.

3. Dry the surface. After surface is dry spray stainless steel cleaner and polish directly on a clean and soft cotton cloth. Cloth should be thoroughly damp but not dripping. Gently wipe in a

HOW TO MAINTAIN THE STAINLESS STEEL SURFACE

1. Inspect surface. The stainless steel cleaner and polish applied (from Initial Cleaning above) provides a protective coat to the stainless steel. Fingerprints and other light marks can be removed by following Step 3 from Initial Cleaning above.

2. Repeat Cleaning Steps. If grease, stains or other difficult to remove spots exist follow Steps 1 through 3 from Initial Cleaning above.

In cases where the above steps outlined do not produce the desired results, it may be a good idea to discuss the issue with an expert in metals. Contact Zahner for larger issues with installed stainless steel.

MAINTAINING STAINLESS STEEL

Stainless steels, specifically the 300 series stainless steel alloys, will develop a protective passive layer and resist corrosion in all normal ambient conditions. However, there are contaminants that, if allowed to stay on the metal surface, can alter the protective layer and render it ineffective. For this reason, it is a good practice to maintain the surface with preventive cleaning, and it is also important to protect the metal during installation to avoid exposure and adherence of adverse impurities.

Note: This guide describes general cleaning and maintenance practices for stainless steel in both interior and exterior environments. For a detailed review of interior cleaning, please refer to the guide for cleaning interior stainless steels as part of the Zahner resource guide.

PREVENTIVE CLEANING

Most exterior uses of stainless steel will perform well with normal rainfall. However, it is recommended to clean the surface once or twice a year particularly after the winter road de-icing period. Environments where de-icing salts are common must be cleaned at minimum once a year. Seaside environments must also receive yearly cleansing. Use mild detergent and warm water. Rinse thoroughly and repeat. Performing this simple task will keep the stainless steel performing well for years.

PRECAUTIONS IN THE FIELD

Extra precautions should be taken when installing stainless steel in a construction environment. Cleaning acids for concrete and stones can cause particular harm to stainless steel and cause corrosion. Likewise precautions for grinding and welding iron-based metals nearby stainless steel. Iron particles that become embedded in stainless steel will oxidize, causing the appearance of rust.

CLEANING STAINLESS STEEL

To properly clean stainless steel it is necessary to first determine what has to be removed and then select the appropriate cleaning procedure. Approaches to cleaning vary considerably; from those jobs that involve simple removal of dirt or smudges that collect on surfaces, to the most complex operations for removing free iron contamination.

Commercial metal cleaners may also be used, but it is important to make certain that they can be used on stainless steel and will not harm any of the surrounding environments. There are numerous cleaning compounds that are available. It is important to test the material that is being cleaned first to make sure that the cleaning compound does not adversely affect the stainless steel finish.

Below is a list of common mild contaminants, and methods for how to clean stainless steel for inks, oils, adhesives, and water scale:

Dirt deposits on stainless steel including dust, dirt, fingermarks, and identification markings are easily removed. Frequently, warm or hot water with or without detergent is sufficient. Do not use carbon steel brushes or steel wool as they will leave particles embedded on the surface that will rust and stain the surface. For slightly more aggressive cleaning, use scouring powder with a small amount of vinegar. Rinsing in clean hot water should always follow cleaning. When water is known to contain mineral solids, which leave water spots, the surface must be dried with soft towels. Caution must be used so the towels do not pick up abrasives and scratch the surface. There are some cleaners and oil impregnated cloths that can also help avoid water spotting.

Inks are typically removed by applying a solvent such as xylene or alcohol. Often the selection of the solvent is based on the type of ink and experimentation for removing and should be tested in an unexposed area if possible. Lastly, the cleaning should be followed by a thorough warm or hot water rinse.

Oils can typically be removed using isopropyl alcohol or xylene. In cases where these solvents don't work, acetone, methyl or ethyl alcohol, toluene, and mineral spirits will be more effective, but require some precautions. These solvents are flammable and may leave behind a residue. It is important to remove all of the contaminant and the residue by using a warm or hot water rinse or pressure spray. Furthermore, there are many over-the-counter cleaners that contain some of these solvents. It is important to try them in a limited and preferably unexposed area prior to any extensive cleaning.

Adhesives are best removed using alcohol, xylene, or mineral spirits. It will often leave streaking; therefore, should be followed with a glass cleaner or similar cleaner that utilizes ammonia. If the adhesive is dry and not softening up with the mineral spirits, there are many cleaners in the marketplace that remove stubborn adhesives. It is important to try them in a limited and preferably unexposed area prior to any extensive cleaning.

Water scale is best removed using vinegar followed with an ample amount of warm water. If that does not remove the scale, a mild abrasive may be required. Caution needs to be taken so that the material is not scratched contrary to the original finish on the stainless steel. Lastly, if the scale is persistent, a cleaner that contains a phosphoric acid or citric acid should remove the scale. It is important to follow the precautions for the cleaner and to flush the surface with warm water.

Each of the above contaminants are mild, and can be cleaned with these simple methods. Below are a listing of harsher contaminants which may require replacement if not mitigated.

SIGNS OF CORROSION

When corrosion occurs on stainless steel it is due to free iron particles on the surface or chlorine attack. Corrosion manifests itself as small brownish spots, often covering large areas of the surface. Corrosion can also occur on the surface when small steel particles are transferred to the surface from improper handling or tooling, or exposure to chlorides. These corrosion conditions can lead to pitting on the surface. Intergranular corrosion develops in severe environments. It occurs when carbide precipitation has weakened the passivity of the surface. The corrosion attack occurs at the grain boundaries of the stainless steel usually in regions around welds.

Crevice corrosion occurs at the joints with nonmetal materials such as gaskets and seals. The passive film is inhibited by the nonmetal materials and when foreign matter (in particular chloride or sulfide salts) migrates to the crevice and lead to the formation of electrolytic cells. If moisture is prevented from collecting in the crevice, corrosion will cease or proceed at a lessened rate. This condition primarily occurs when the gasketing is porous or the sealants cannot react properly to movement. Oftentimes the exposed surface shows little indication of the corrosion. Sometimes it will show itself as rust leaching out of a gasket or sealed condition.

MILD RUST

These problems are on the more severe end of the need to clean spectrum and obviously take a more aggressive cleaning process. When iron particles get embedded into the surface and start to oxidize they show up on stainless steel as a dark spot. If left unchecked, they can form pits in the surface of the stainless steel that cannot be removed easily. In order to try to remove the surface contaminant, you should utilize a cleaner that includes a phosphoric, oxalic, or sulfamic acid. Oftentimes the acid must maintain contact with the surface in order to completely remove the rust. It is important to flush the surface with copious amounts warm water to insure that the acid is completely removed. Furthermore, care must be taken to control the flow of the effluent so it does not stain or harm any surfaces below. It is important to follow the precautions regarding any of these cleaners that contain acid.

WELD DISCOLORATION

For a situation where a weld joint exposure is unavoidable, the first attempt should be to try a mild abrasive cleaner with phosphoric acid. If this does not completely remove the discoloration, an electrolytic weld cleaning process can be used, but that should be performed by someone familiar with using that specific piece of equipment. After the discoloration is removed, it is important to flush the area with warm water.

In the case of severe corrosion, it is often necessary to dis-assemble the stainless steel parts so a more thorough cleaning can occur via acid immersion. These cleaning processes often require a re-passivation of the surface so it is recommended that this process be performed by an expert with stainless steel. Remember crevice corrosion occurs around improper bolts or washers being used that can trap contami-nants and moisture. Proper gasketing or the change in the fastener type can improve the chances to avoid further corrosion significantly.

CHLORIDE CONTAINING SOLUTIONS

Chloride containing solutions, including hydrochloric acid based cleaning agents and hypochlorite bleaches can cause unacceptable surface staining and pitting, and should not be used in contact with stainless steels. Under no circumstances should concentrated bleaches contact decorative stainless steel surfaces. Hydrochloric acid based solutions, such as silver cleaners, or building mortar removal solutions must not be used in contact with stainless steels. Hypochlorite containing bleaches must be used in the solutions suggested in the manufacturer's instructions and contact times kept to a minimum. Thorough rinsing after use is very important.

CONCLUSION

There are often simple procedures and over–the-counter cleaners to keep stainless steel surfaces clean and like new. The keys to maintaining the stainless steel finish are:

- Clean the contaminants from the surface immediately.
- Avoid abrasives where possible.
- Test clean in less exposed areas.
- Flush with warm or hot water after cleaning.