

METAL FINISHES MANUAL

*For Architectural
and Metal Products*



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Full document details: NAAMM AMP 500 2006

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Acknowledgement

NAAMM and NOMMA wish to thank their members and officers as well as industry experts for assistance and cooperation in producing this edition of the *Metal Finishes Manual*.

Introduction To Metal Finishing

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INTRODUCTION TO METAL FINISHING

The variety of finishes used on architectural metals, like other aspects of building technology, becomes increasingly complex. Recognizing the need for organized information on this subject, the National Association of Architectural Metal Manufacturers (NAAMM) published the first edition of this Manual in 1964. A second edition was published in 1969, a third edition in 1976, and a fourth edition in 1988. In response to the continuing demand for the Manual, this edition, containing still further revisions, is being published jointly by NAAMM and the National Ornamental & Miscellaneous Metals Association (NOMMA).

The scope and nature of this edition are the same as those of the former editions, but all of the contents have again been carefully and critically reviewed. Obsolete data has been deleted, errors have been corrected, references to standards and supplementary sources of information have been updated, and the text has been extensively revised to reflect current practices.

The Manual consists of five chapters and an Introduction to Metal Finishing, which briefly explains the applicability of the various finishes for architectural applications. The first four chapters cover finishes for the specific architectural metals, aluminum, the copper alloys, stainless steel, and carbon steel and iron respectively. Chapter 5 covers applied coatings used on all metals.

It is still the prime purpose of the Manual to provide the architect with essential information about the many finishes available, and to assist him in selecting and properly identifying them. It is intended as a reference handbook, dealing briefly with all of the finishes commonly used, but not attempting to provide complete information about them. With the many new developments constantly occurring, a small volume such as this can serve only as an introduction to this very broad subject. For those desiring more comprehensive information, numerous references to supplementary sources are provided.

The production of satisfactory finishes on architectural metal requires teamwork and cooperation among the metal supplier, the fabricator, the

finisher, the architect and the contractor. It is not the sole responsibility of any one of these parties. The architect must understand the characteristics and limitations of the many finishes available, so that he may select those which are proper and appropriate for his purposes, and he should be able to clearly define his requirements. It is the responsibility of the supplier and fabricator to interpret these requirements sympathetically, to furnish the appropriate alloys, and to see that all necessary steps are taken to produce the desired effects.

The contractor must see that the finishes supplied are handled and installed with care, and are properly protected after installation. A satisfactory end result is the common aim of all parties, but a lack of mutual understanding can easily result in dissatisfaction. One of the aims of this Manual is to minimize the likelihood of such deficiencies by encouraging a better common knowledge of the subject, for the benefit of all concerned.

General Classification of Finishes

All of the finishes commonly used on the architectural metals can be classified as one of three principal types:

Mechanical Finishes, which are the result of physically affecting the surface of the metal by some mechanical means. This means may be the forming process itself, or a subsequent operation performed either before or after the metal is fabricated into an end use product.

Chemical Finishes, which are accomplished by means of chemicals, and which may or may not have a physical effect upon the surface of the metal.

Coatings, which are applied as finishes, either to the metal stock or to the fabricated product. These coatings may be either:

- a) Formed from the metal itself by a process of chemical or electrochemical conversion, or
- b) Formed by the application of some added material.

The relative importance of the three basic types of finish varies with the different metals. They are all used extensively on aluminum, but on carbon steel and iron, the coatings are far more important than either mechanical or chemical finishes. The copper alloys are commonly subject to both mechanical and chemical finishes. On stainless steel the mechanical finishes are the common standard, while chemical finishes and coatings are infrequently used. Table 1 - Comparative Applicability of the Various Types of Finishes provides an overall view of the extent to which the various types of finishes are normally used on the different metals.

Because many of these finishes are not distinctly or uniquely suited to any one metal alone, and usages overlap considerably, the subject has not been found to lend itself to a neatly compartmented treatment, arranged either by metals or by finishes. It has seemed advisable, therefore, to classify the bulk of the discussion according to metals, treating under each metal not only those finishes which are uniquely its own, but also the mechanical and chemical finishes as applied to that metal. This necessarily involves some repetition of basic information regarding the more common finishes, but these overlaps seem justifiable in the interests of providing optimum clarity and minimizing the need to refer from one chapter to another. With certain types of applied coating, however, the chief concern centers on the coating itself, rather than on any particular substrate, and it has seemed advisable to discuss such finishes under the heading of Applied Coatings, rather than identifying them with any one metal. Thus the typical mechanical and chemical finishes, as well as the unique coating finishes for each of the metals are discussed in Chapters 1 through 4 under headings identified by the metals, along with the designation system used for denoting these finishes. The organic, laminated, and vitreous coatings, however, being generally applicable to several metals, receive separate consideration in Chapter 5.

The Function and Source of Finishes

The function of metal finishes may be protective, decorative or both. A majority of the many surface treatments identified in this Manual as “finishes” are not, in fact, final treatments, but only intermediate steps in a finishing process. Many

are applied for protective reasons, some for reasons of appearance, and a few are simply cleaning processes. Usually several steps are required in preparing a metal surface for its specified end use condition. All of these steps are designated, in the terms of the trade, as “finishes,” though only the final treatment is actually exposed to use; the others are in fact simply preparatory treatments. This is often the case, for example, where compound finish designations are the general rule, as is explained in Chapters 1 and 2.

Only a few of the many finishes discussed are provided by the basic suppliers of the metal. In the main, these are the so called “as fabricated” finishes, which are usually the cheapest form of mechanical finish, and are available on all of the metals. Sheet stock of various metals is also available from the basic suppliers with several types of applied coatings, and aluminum and stainless steel sheet are supplied also with embossed and coined patterned textures. All of the other finishes are “process finishes,” and are applied by the manufacturer or fabricator of the product or by other companies specializing in finishing work. The quality of finish on many architectural products depends largely, therefore, on the skill of the fabricator or finisher rather than on the basic supplier, but the quality of the alloys furnished by the supplier is always a factor of prime importance.

Variations in Appearance; The Value of Samples

Visual appearance is often a major concern with metal finishes, and uniformity of appearance may be critical in many architectural applications. Some types of finish present no problems in this latter respect, while others are subject to slight variations. Uniformity of appearance is often dependent upon the alloys used, and in certain mechanical finishing processes it is affected also by the equipment and speeds used in the finishing operation itself. With the non ferrous metals, the achievement of a desired result often depends as much on specifying the right alloy as on choosing the right finish.

With rigid control of such variables, a high degree of uniformity can be achieved in any finish, but the architect should recognize that, except with opaque coatings, it is unrealistic to expect perfect uniformity of color and texture, particularly if the finish is provided by different parties or from different stocks of metal. For this reason it is rec-

ommended that the supplier or fabricator should always be consulted concerning critical requirements. The use of representative samples is usually advisable, too, as a means of describing requirements in applications where precise control is essential. When color is involved, at least two samples should be used, to define the permissible range of color.

The Choice of a Finish

A good working knowledge of metal finishes requires more than an understanding of the technicalities of their processes and the ability to designate them properly. If the architect is to specify them intelligently he or she will be concerned not

only with the esthetic effect desired, but also with their practical appropriateness and their relative costs as well.

These finishes vary considerably in the amount of labor they require, and consequently in their costs. Frequently money is wasted in the use of unnecessarily expensive finishes in locations where they can't be distinguished, and sometimes the choice of impractical finishes has needlessly complicated production processes, resulting in objectionable delays and expenses. On the other hand, some important jobs have suffered because of the unwise selection of a "low cost" finish or the arbitrary decision to avoid the relatively insignificant cost of a critical finishing operation.

Precautions

An attempt has been made in this Manual, by the prominent listing of "Precautions," to specifically point out the limitations inherent in certain types of finishes, and to indicate their most appropriate applications as well as their relative costs. It is hoped that the architect will find this information helpful in using all of the architectural metals more effectively.

**TABLE 1 - COMPARATIVE APPLICABILITY OF THE VARIOUS FINISHES
FOR ARCHITECTURAL APPLICATIONS**

	Type of Finish or Treatment	Metal			
		Aluminum	Copper Alloys	Stainless Steel	Carbon Steel and Iron
MECHANICAL FINISHES	As Fabricated	-----common to all of the metals----- <i>(produced by hot rolling, cold rolling, extruding or casting)</i>			
	Bright rolled	-----commonly used----- <i>(produced by cold rolling)</i>			Not used
	Directional grit textured	-----commonly used----- <i>(produced by polishing, buffing, hand rubbing, brushing or cold rolling)</i>			Rarely used
	Non-Directional matte textured	-----commonly used----- <i>(produced by sand or shot blasting)</i>			Rarely used
	Bright polished	-----commonly used----- <i>(produced by polishing and buffing)</i>			Not used
	Patterned	-----available in thin sheets of all metals-----			
CHEMICAL FINISHES	Non-etch Cleaning	-----commonly used on all of the metals-----			
	Matte finish	Etched finishes Widely used	Seldom used	Not used	Not used
	Bright finish	Limited uses	Rarely used	Not used	Not used
	Conversion coatings	Widely used as pretreatment for painting	Widely used to provide added color variations	Not used	Widely used as pretreatment for painting
COATINGS	Anodic <i>(See Ch 1)</i>	Traditional type of finish	Not used	Not used	Not used
	Organic <i>(See Ch 5)</i>	Widely used	Opaque types rarely used; transparent types common	Sometimes used	Most important type of finish
	Vitreous <i>(See Ch 5)</i>	Widely used	Limited use	Not used	Widely used
	Metallic <i>(See Ch 4)</i>	Rarely used	Limited use	Limited use	Widely used
	Laminated <i>(See Ch 5)</i>	Substantial uses	Limited use	Not used	Substantial uses

Chapter 1: Finishes For Aluminum

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FINISHES FOR ALUMINUM

General

Aluminum is unique among the architectural metals with respect to the large variety of finishes used. Nearly all of the finishing processes discussed in this Manual, in fact, are not only appropriate but commonly used for this metal, whereas some of them are seldom if ever applied to other metals. Those used on aluminum include several varieties under each of the three major types of finishing processes, as shown in the following summary. The mechanical, chemical and anodic coating finishes, along with their descriptions and standard designations, are explained in detail in this chapter. The other coating

finishes, which are used on other architectural metals as well, are discussed in detail in Chapter 5, Applied Coatings.

Note that most of the finishes in the following Summary are not applied by the prime producers of aluminum, but by other processors or by the manufacturers of the end use products. The only true mill finishes, in fact, are the "As Fabricated" finishes, though some producers also supply sheet and coil stock with organic and laminated coatings, as well as patterned sheet. All of the other finishes are referred to as process finishes, being applied by others after the metal leaves the mill.

SUMMARY OF TYPICAL ALUMINUM FINISHES

Finish	Aluminum Association Finish Designation (see page 14)	Finish Normally Supplied By			Relative Costs (on flat surfaces)
		Mill	Proces- sor	Fabricator or Finisher	
MECHANICAL					
As Fabricated	M10 Series	X			base
Buffed	M20 Series			X	wide range ¹
Directional Textured	M30 Series			X	wide range
Non-Directional Textured	M40 Series			X	wide range
Patterned	MnX (Specify)	X	X		low to medium ²
CHEMICAL					
Cleaned only	C10 Series		X	X	very low
Etched	C20 Series			X	very low
Brightened	C30 Series			X	very low
Conversion Coatings	C40 Series	X	X	X	very low
Other	CnX (Specify)	X	X		low to medium ²
ANODIC COATINGS					
General	A10 Series		X	X	medium to high
Protective/Decorative	A20 Series		X	X	medium to high
Architectural Class II	A30 Series			X	medium to high
Architectural Class I	A40 Series			X	medium to high
Other	AnX (Specify)				
Electroplated and Other Metal	E Series				
ORGANIC COATINGS					
Resinous (See Chapter 5)	R Series	X	X	X	low to medium
Vitreous (See Chapter 5)	V Series		X	X	high
Laminated (See Chapter 5)	L Series	X	X		medium

The term PROCESSOR, as used here, refers to a "middleman" between the mill and the fabricator, who applies coatings, textures or other finishes to metal in bulk form, generally cut sheet or strip or coil stock. FABRICATOR refers to the producer of stock metal shapes or the manufacturer of the end-use product. He either provides the final finish, or sends the fabricated product to a finisher who does this work. The FINISHER does not usually fabricate products, but provides finishes as specified, to products fabricated by others.

The RELATIVE COSTS indicated are necessarily approximate, for general guidance only. Exact costs vary considerably with quantity, type of product, method of application, quality of work and other influences, and should always be verified.

¹ If these finishes are applied by automatic means in production lines, the cost is generally low, but if applied by hand methods, as is sometimes necessary, it can be relatively high.

² Certain embossed patterns, because of their stiffening effect, permit the use of thinner metal, and this saving can in some cases offset their cost. In other cases patterned finishes involve extra costs.

Mechanical Finishes

Mechanical finishes are those that involve the use of no chemical or electrochemical treatment and no additive but provide a surface texture by mechanical means alone. These textures vary widely in character, ranging from the surface appearance resulting from the various production processes to highly reflective surfaces produced by successive grinding, polishing and buffing operations, with costs also varying considerably, in proportion to the amount of processing required.

“As Fabricated” Finishes

The term “As Fabricated” can refer either to the metal stock or to a fabricated product. As a finish designation for aluminum stock it refers to the surface appearance and texture imparted to the metal by the rolling mill, extrusion press, or casting mold which shapes it. Subsequent fabrication operations on the aluminum, such as forming, sawing, punching, drilling, milling, etc., including scratches, can mar the “as fabricated” finish. Under some conditions the marring can be corrected by simple mechanical deburring and smoothing. For other conditions, the marring results in an unacceptable “as fabricated” mechanical finish, and a subsequent finishing operation will be required and should be specified. The subsequent operations most commonly specified for aluminum are a smooth specular buffed finish or a medium satin directional textured finish. Where welding is required on exposed surfaces, discoloration and surface irregularities will result. Discoloration on etched or anodized surfaces resulting from welding cannot be removed.

“As Fabricated” mechanical finishes, as a class, are the simplest and least expensive obtainable. Such finishes can be quite acceptable for architectural applications and are widely used. Typical of these are specular “as fabricated” cold rolled sheet and nonspecular “as fabricated” extrusions. Highly polished rolls used at the mill for the final pass provide the specular finish on the cold rolled sheet. Carefully machined and well maintained dies for the extrusion press ensure extruded surfaces free of objectionable die marks or striations.

The uncontrolled natural finishes resulting from the different forming processes vary somewhat according to the process. Hot rolled and heat treated products have a comparatively dull surface finish and show a certain amount of darkening or discoloration, while cold rolled surfaces have a

brighter and more metallic color. Extruded products have an intermediate appearance, somewhat resembling that of cold rolled items, and can have noticeable surface striations caused by the extrusion die. Castings have a rougher matte finish, die castings being the smoothest and sand castings the roughest.

The typical variations of the “As Fabricated” finish can be identified as follows:

- a) **Unspecified:** This is the natural finish provided by extrusion, casting, hot rolling or cold rolling with unpolished rolls. On rolled products it can vary from dull to bright, and can have stains or light films of rolling oil.
- b) **Specular as fabricated:** A mirror like cold rolled finish, produced on one or both sides of sheet by final passing through highly polished rolls. Not applicable to extrusions, forgings or castings.
- c) **Nonspecular as fabricated:** This is a designation used to refer to a more uniform finish than that provided under the “Unspecified” classification but lacking the specularity of the “Specular as fabricated” finish.

Buffed Finishes

These finishes are generally produced by successive processes of grinding, polishing and buffing, or by buffing alone, if the “as fabricated” finish is acceptably smooth. They are used where a top quality bright appearance is required, and are frequently specified for entrance doors and their framing or for highlighting extrusions and patterned sheet, as well as for hardware. Because of their high reflectivity they should not be used on wide flat surfaces. The cost of these finishes varies widely with the complexity of the product and the number of steps required to achieve the desired effect.

These are process finishes, applied by the fabricator or finisher, and among the many variations possible, two types are generally considered as standard:

- a) **Smooth specular** (mirrorlike): This is the brightest mechanical finish obtainable and is produced by buffing. In order to achieve this lustrous finish the surface is ground and/or polished in one or more stages prior to buffing. When this is required, the final finishing prior to buffing is done with 320 grit.
- b) **Specular:** This finish is accomplished by buff-

ing only, no preliminary grinding or polishing operations being necessary. The resulting finish can show some evidence of scratches or other surface irregularities.

Directional Textured Finishes

Finishes of this type are used in many applications where a smooth satiny sheen of limited reflectivity is desired. The characteristic soft texture results from tiny, nearly parallel scratches in the metal surface produced by wheel or belt polishing with fine abrasives, by hand rubbing with stainless steel wool, or by brushing with abrasive wheels. Always be sure when using any metal finishing materials to clean the aluminum prior to any anodizing process. In belt polishing, the fineness of the finish is controlled by the size of the grit used, the speed of the belt, the hardness of the block or pad used, the pressure exerted on the block, and the condition of the belt.

These are all process finishes, and generally five standard types are recognized:

- a) **Fine satin**
 - b) **Medium satin**
 - c) **Coarse satin**
- These finishes are produced by wheel or belt polishing with grits of varying degrees of fineness.
- d) **Hand rubbed:** This is another type of satin finish obtained by rubbing with abrasive cloths or with stainless steel wool of increasing degrees of fineness, finishing with No. 0 or No. 00. Hand rubbing is a comparatively expensive finishing process, and is used only where the nature of the work being finished makes other methods impractical. It is frequently employed, however, to even out and blend in satin finishes produced by other means. Again, when using any metal materials in finishing, be sure to clean before any anodizing process.
 - e) **Brushed:** Several varieties of directional finish with approximately parallel scratch lines can be produced by using power driven stainless steel wire wheel brushes, brush backed sander heads (Vonnegut wheels), abrasive impregnated foamed nylon discs (Scotch-Brite®), or abrasive cloth wheels (PG wheels). Again, when using any metal materials in finishing, be sure to clean before any anodizing process.

Non Directional Textured Finishes

These are matte finishes of varying degrees of roughness, produced by blasting sand, glass beads, or metal shot against the metal under controlled conditions. Their principal use in architectural work is on items produced by casting.

The texture of the surface is determined by the size and type of abrasive used, the amount of air pressure, and the position and movement of the nozzle. The finer the abrasive the smoother the finish. A comparatively rough finish is obtained by using coarse silica sand, while the smoothest finishes are obtained by dust blasting with a very fine abrasive and by "vapor honing" with a slurry of extremely fine abrasive and water.

The architect should recognize that these finishes produced by blasting have restricted applicability. Because the impingement of the abrasive under pressure tends to distort the metal, their use is not recommended on material less than ¼ in. (6 mm) thick. There is usually difficulty, too, in obtaining uniform appearance, especially after anodizing, unless special equipment is used to regulate pressure and nozzle movement.

Since the surface produced by even the finest abrasive is actually rough, readily shows fingerprints, and collects and retains dirt, some type of protective treatment is necessary to retain a clean appearance. Clear lacquers are often used for this purpose, and anodizing provides an excellent protective coating, particularly on castings, where such finishes are most appropriate.

The common variations of the sandblasted finishes obtained by using washed silica sand or aluminum oxide of different degrees of fineness are:

- a) **Extra fine matte**
- b) **Fine matte**
- c) **Medium matte**
- d) **Coarse matte**

Shot blasting is used to provide peened finishes. By using steel shot of different sizes the following standard variations are produced:

- e) **Fine shot blast**
- f) **Medium shot blast**
- g) **Coarse shot blast**

Note: steel shot can become impregnated in aluminum causing a problem of dissimilar metals. This also will cause serious problems during the anodizing process.

Patterned Finishes

Patterned finishes are available in thin sheet, in a wide variety of sculptural designs and textures. These are produced by passing “as fabricated” sheet either between two machined matched design rolls, impressing patterns on both sides of the sheet (embossing), or between a design roll and a smooth roll, “coining” one side of the sheet only.

Some coined and embossed patterns are available from the mill; others are produced only by secondary processors.

Chemical Finishes

There are numerous methods of providing intermediate process finishes on metals by washing or dipping the fabricated product in chemical solutions, and many of these are of a proprietary nature. Such treatments have a variety of specific purposes, but in general they are used

- to merely clean the surface, without otherwise affecting it.
- to provide a clean matte textured surface (by etching),

PRECAUTIONS

Regarding the Use of Mechanical Finishes on Aluminum

An “As Fabricated” finish is the finish on the metal as it is received from the rolling mill, roll former, extrusion press, or casting mold, prior to any further mechanical, chemical, anodic, organic, or vitreous finishing operation. In many architectural applications this finish will be acceptable without further mechanical finishing. However, in some products, fabrication operations subsequent to the original as fabricated finish, such as forming, sawing, punching, drilling, milling, etc., can mar the finish so that it is unsatisfactory for architectural applications.

Clad sheet should not be mechanically finished because of the possibility of penetrating such products. It will be necessary to perform additional mechanical finishing operations, and these should be specified for the cladding.¹

Buffed finishes are not recommended for broad surfaces where visual flatness is desired. The high reflectivity of these surfaces accentuates the waviness or oil canning caused by forming operations or temperature changes and can be objectionable. The use of patterned or etched sheet, with or without formed contours, is advised for such applications.

Bright finishes accent all surface blemishes while satin finishes tend to minimize surface blemishes.

Sandblast finishes should not be specified for thin sheet because distortion usually results.

Chemical etching will usually cause noticeable discoloration at welded joints regardless of mechanical or anodic finishes. Where etching and anodizing are to be used, the product, if possible, should be designed so that welded joints are not exposed. The degree of discoloration will depend on both the parent alloy and the filler alloy used for welding. In the selection of filler alloys ease of welding, strength of joint, color matching, and the effect of subsequent heat treatment are factors which must be considered. Some combinations of parent alloys and filler alloys can provide acceptable color matching but not provide adequate strength, and vice versa. Information on this subject is available from The Aluminum Association, or contact the finisher.

All surface protective coverings such as non-adhesive papers, adhesive papers, and stripable plastic films should be removed after receipt at the site as soon as there is no longer a need for the protection. These coverings can affect the surface finish and become brittle and unpeelable under exposure to sunlight and the elements as well as cause staining on the finished product.

¹To improve the finishing characteristics and increase the corrosion resistance of certain alloys in sheet and plate form, they are sometimes “clad” with other aluminum alloys. The thickness of the cladding on each side is usually 5% or less of the total thickness, hence it can be penetrated by abrasive processes.

- to produce a smooth, bright finish, or
- to chemically convert the surface of the metal, providing a film which is a good substrate for organic coatings.

Many types of chemical treatment are used on aluminum as finishing processes, but few of these are in themselves true finishes. Most of them are intermediate steps in an overall finishing process, requiring at least the subsequent application of some form of protective coating.

Non-etch Cleaning

Various chemical treatments are widely used to thoroughly clean the metal preparatory to the application of other finishes. These have no physical effect upon the surface of the metal, and can not be classified as true finishes. They produce a chemically clean surface which is free of all foreign matter such as oil, grease, fingerprints, solid particles of any kind, tarnish, other chemical reaction products, and even surface absorbed gases. Such preparatory cleaning is essential for the successful application of any type of additive coating.

Two such cleaning methods are commonly used:

- Degreasing:** Vapor degreasing exposes the metal to vapors from chlorinated solvents such as trichlorethane and perchlorethylene, and is performed in special degreasing machines. Solvent or solvent emulsion cleaning, with hydrocarbon solvents, is used to remove oil and grease from the metal surface, and is less expensive than vapor degreasing. To achieve maximum cleanness, degreasing of any type should be followed by chemical cleaning. Check to see if this method is subject to EPA regulations.
- Chemical cleaning:** This method is used when animal fats and oils must be removed. The metal can be sprayed with, or immersed in, any number of proprietary or non proprietary solutions, usually at elevated temperatures, after which it is rinsed with water. Inhibited chemicals are used on aluminum, to prevent etching of the surface. Solutions used on ferrous metals are usually not appropriate because of their etching effect. Most of the commonly used cleaners are special detergent products.

Matte Finishes

Finishes of this type are referred to as etched finishes in the aluminum industry, where chemical etching is a very common finishing treatment. The so-called “frosted” finishes are obtained by this means, and the etching process is often used also to prepare surfaces for anodizing. Where a less durable finish is acceptable, the etching can be followed by simply the application of a protective coating of clear lacquer.

These finishes change the surface texture of the metal from a metallic shine to a satin or dull sheen, and are regulated to give varying degrees of roughness. This controlled surface roughening can be accomplished either by alkali solutions with various additives or by various acid solutions. Where production quantities are involved, the cost of obtaining satin finishes by such means is usually much less expensive than that of producing them mechanically. However, for short runs, or when dealing with assemblies of various metals or large assemblies with only small areas to be finished, mechanical methods may be preferable.

A wide variety of acid and alkaline etches is used, producing various degrees of matte finish. The more common of such standard finishes are:

- Fine matte:** This finish is produced by using a mild alkali solution such as trisodium phosphate.
- Medium matte:** The most common “caustic etch” finish, obtained by treating the surface with sodium hydroxide (caustic soda).
- Coarse matte:** This finish is generally produced by using a solution containing sodium fluoride plus sodium hydroxide.

Bright Finishes

A variety of bright finishes, ranging from “mirror bright” to “diffuse bright,” are produced either by chemical brightening, obtained by immersing the metal in certain acid solutions, or by electrolytic brightening—both methods producing visually similar results.

In electropolishing, minute irregularities in the metal surface are removed by making the article to be brightened the anode in an electrolyte. This process produces surfaces that are free from mechanical stresses and embedded abrasive particles, and also results in a somewhat different appearance than that produced by mechanical buffing.

For aluminum products there are two standard types of bright finish, designated as:

- a) **Highly specular:** This finish is the result of preliminary buffing, followed by electropolishing or chemical brightening, and produces a mirror like surface on certain alloys. It is widely used as a finish for reflectors.
- b) **Diffuse bright:** A finish generally produced by first applying a caustic etch (medium matte) finish, followed by chemical brightening.

Conversion Coatings

Although chemical conversion coatings are generally used on aluminum to prepare the surface for painting, some types can also be used as a final finish.

Since the natural oxide film on aluminum surfaces doesn't always provide a good bond for paints, other organic coatings, and laminates, its chemical nature is often "converted" to improve adhesion and undercoating conversion protection. These "conversion films" or "conversion coatings" are generally applied by use of phosphate or chromate solutions, many of which are proprietary in nature. One of the simplest methods of improving the adhesion of organic coatings is to etch the surface with a phosphoric acid solution, thus providing a good mechanical bond.

The conversion "finishes" commonly used are:

- a) **Acid-chromate fluoride treatments**, also provided by proprietary chemicals and result-

ing in either clear or yellowish surface colors. Finishes of this type are usually governed by ASTM B 449, Specifications for Chromates on Aluminum. The proprietary solutions used include Bonderite 714 and 721, Alodine 1200 series, NR2 and NR3, and Iridite 14 and 14-2.

- b) **Acid-chromate fluoride phosphate treatments**, which generally employ proprietary chemical processes and result in either a clear or typically greenish surface color. Among the more common of these processes are Alodine 407-47 and 401-45, and Bonderite 701, the former producing a light green surface suitable as a final finish.

- c) **Acid-chrome free phosphate free fluoride treatments** usually use proprietary chemical processes and produce a clear or iridescent surface color. Among the proprietary finishes of this type is Alodine 4830/4831

NOTE: Alodine, Bonderite and Iridite are registered trade names of Parker/Amchem and Allied Kelite Division of The Richardson Company, respectively.

Anodic Coatings

Probably the most important, and certainly the most unique, of all of the aluminum finishes is that provided by the anodizing process. In essence, the anodizing process consists of immersing the aluminum to be anodized in an appropriate acid solution, referred to as the electrolyte, and passing a direct electric current between the aluminum and the elec-

PRECAUTIONS

Regarding the Use of Chemical Finishes on Aluminum

Proper pretreatment is absolutely essential to the satisfactory performance of the subsequently applied finishes. For organic coatings it should take place immediately prior to the application. Strict quality control is a necessity throughout the process.

Chemically brightened finishes for large surfaces such as fascias and spandrel panels can cause handling problems and some difficulty in obtaining uniformity under production conditions.

Chemical finishing of assemblies involving different metals or alloys is usually impractical because each of the different metals or alloys is likely to be affected differently.

All surface protective coverings such as non-adhesive papers, adhesive papers, and strippable plastic films should be removed after receipt at the site as soon as there is no longer a need for the protection. These coverings can affect the surface finish and become brittle and unpeelable under exposure to sunlight and the elements.

trolyte, with the aluminum acting as the anode. This results in the controlled formation of a durable oxide film or coating on the surface of the aluminum. In general, such coatings are many times thicker than the naturally formed oxide film and can be transparent, translucent or opaque, depending on the alloys and/or processes used. Anodic coatings do not affect the surface texture of the aluminum, however fine this texture is, but they greatly increase resistance to corrosion and provide increased resistance to abrasion.

Proper surface treatment prior to anodizing is essential. This will require the use of the appropriate chemical cleaning and finishing processes described under **Chemical Finishes**. If soil or grease are present their removal by vapor degreasing or inhibited chemical cleaner is the first requirement. All metal residue from finishing or grinding must also be removed. Chemical etching or brightening are commonly used following the cleaning where the final appearance requires such preanodizing treatments. Etching is the most economical and most extensively used pre finish. Its matte appearance is not only attractive, but it effectively conceals minor surface marring.

Pre anodizing treatments can receive one of the buffed, directional, non directional or patterned finishes described under **Mechanical Finishes**. However, "as fabricated" mill finishes on both sheet and extrusions are of a quality that eliminates the need for a subsequent mechanical finishing operation. Because of this, most architectural products today are simply etched and anodized.

Several different anodizing processes are presently used for architectural aluminum products. The principal differences in these processes are the solutions used for the electrolytes, the voltages and current densities required, and the temperature at which the electrolyte is maintained. Depending on which process is used, and the length of treatment time, the anodic coating will vary somewhat in thickness, hardness and porosity. Because of this there are some differences in the protective capabilities of the different coatings.

Clear anodic coatings are produced by the **sulphuric acid process** which was the first commercially used process for anodizing architectural aluminum. It imparts an excellent, comparatively thick, transparent, durable, protective coating to the aluminum surface, and it is economical.

Color anodic coatings are obtained by impregnating the coating with organic dyes or pigments, by using alloys and processes that produce integral color, or by electrolytically depositing pigments in the anodic film. The clear anodic coatings produced by the sulfuric acid process are suitable for accepting a wide variety of organic dyed colors considered sufficiently resistant to ultraviolet degradation for exterior use.

Integral color anodic coatings in the bronze-grayblack range are produced by both the basic sulfuric acid process and by proprietary mixed acid processes. These colors are durable, have good resistance to ultraviolet, and are widely used for exterior applications of architectural aluminum products. One such process also goes by the title Duranodic Process.

In the basic sulfuric acid anodizing process, integral colors can be obtained with certain controlled alloys and by employing lower temperatures and higher current densities than those used in the conventional process. Coatings so produced are referred to as integral color hardcoats. With proprietary mixed acid electrolyte processes, controlled alloys and higher current densities are also used, and temperatures are closely controlled as are the concentrations of the mixed acids. With mixed acids, integral colors can be obtained without the relatively low temperatures required for the sulfuric acid process, hence they are more economical to produce. The color and the shade of the oxide coatings produced by these processes are determined by the composition and temper of the alloys used, by the concentration of acids in the electrolyte, and by anodizing conditions such as time, temperature, and current density.

Brite Dip Anodizing is used primarily in the bathroom fixture industry. This 'brite' finish is accomplished by a mixture of Nitric acid and Phosphoric acid. The vapors from this process are environmentally hazardous and not available everywhere. There is a chemical brightening process, basically electropolishing, that is starting to replace the older more hazardous process when this brite appearance is requested.

Electrolytically deposited anodic coatings are produced by proprietary processes used in conjunction with sulfuric acid anodizing and provide colors in the light bronze to black range, similar to those produced by integral color processes and equally appropriate for exterior use.

The colors, as the name of the process implies, are obtained through the electrolytic deposition of colorfast, stable, metallic pigments in the base of the pores of the anodic coating by submersion in a metal salt bath, such as cobalt or tin, under low power.

For architectural applications the thickness and weight of the coating are of prime importance. Coatings specified for exterior applications exposed to atmospheric pollutants, or not having regular maintenance, should have at least 0.7 mil thickness and a minimum coating weight of 27 mg. per square inch. For resistance to extreme exposure conditions such as sea water or abrasive actions, integral color hardcoats up to 3.0 mils thick have been used.

In all of the architectural anodizing processes the subsequent sealing of the pores in the oxide coating is a prime essential. The sealing of the pores is done to make the coating nonabsorbent and to provide maximum resistance to staining and corrosion. Clear, integral color and electrolytically deposited color coatings are usually sealed in deionized boiling water or metal salt sealants.

Surfactants and wetting agents can be used, but they should be controlled so as not to cause poor adhesion of any organic overcoating.

Classification of Anodic Coatings

For purposes of identification, the various anodic finishes are classified by the Aluminum Association under four general types: General Anodic Coatings, Protective and Decorative Coatings, Architectural Class II Coatings and Architectural Class I Coatings. Each of these classifications has several subdivisions, as shown in Table 1-5, page 1-21.

The first two classifications apply to general industrial work, not to architectural products. Only the last two, as their names indicate, are of architectural interest and will be described here.

Architectural Class I Coatings

These are coatings 0.7 mil or more in thickness and weighing not less than 27 mg. per sq. in., or a density not less than 38 g per sq in., and include the hardest and most durable anodic coatings available. They are appropriate for interior architectural items subject to normal wear, and for exterior items that receive a minimal amount of cleaning and maintenance. It is possible to produce hard coat Class I finishes in thicknesses ranging from 1 to 3 mils.

Coatings in this range have been used successfully in such applications as railings on piers which are subject to severe salt water exposure. However, production of these thick hard coat finishes requires special anodizing facilities of which there are only a limited number in this country. Availability should be checked. Please note that the heavier Class I coating will actually enhance surface imperfections and blemishes rather than hiding them.

Architectural Class II Coatings

Thickness of these coatings ranges from 0.4 to 0.7 mils, with corresponding weights of from 15.5 to 27 mg per sq in., or a density ranging from 22 to 38 g per sq in.; the lower figures being the minimums recommended for architectural uses. Coatings of this class are appropriate for interior items not subject to excessive wear or abrasion, and for exterior items such as storefronts and entrances, which are regularly cleaned and maintained.

Quality Control Tests

After anodizing is completed, tests are performed on representative samples taken at random from the rack loads to determine that the coating meets the specified thickness and weight and is properly sealed. The following *ASTM Test Methods* for checking thickness and weight are universally accepted and recommended, and should be specified:

- *ASTM B 244, Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy Current Instruments.* This non destructive method determines coating thickness by the lift off effect of a probe coil that contacts the coating and generates eddy currents in the aluminum substrate.

- *ASTM B 137, Test Method for Measurement of Weight of Coating Mass per Unit Area on Anodically Coated Aluminum.* This test involves weighing a small sample of known surface area on an analytical balance, dissolving the coating in a solution that does not attack the aluminum, then reweighing the specimen and comparing weights.

Properly sealed anodic coatings are proof against absorption of coloring materials or staining. To check for proper sealing the following stain test can be used:

- *ASTM B 136, Test Method for Measurement of Stain Resistance of Anodic Coatings on Aluminum.*

PRECAUTIONS

Regarding the Use of Anodic Coatings on Aluminum

Anodic coating can be restored only by removing the coated item and refinishing it in the shop, at the cost of considerable time and expense. Items subject to heavy wear or abrasion should therefore either receive a sufficiently heavy coating to insure that it will not be worn through, or should be given some other type of finish that can be more easily restored,

Flash welding can be successfully done on frontal areas to be anodized, providing the “flash” is mechanically removed, but arc welding of assemblies to be anodized should be done only in concealed areas, because objectionable discoloring can result. If required, it should be undertaken only with the advice of a competent and experienced fabricator. The selection of filler rod for welding is also very important. If the wrong material is used, any exposed weld joint can turn black in the anodizing process. The most common filler rod if the aluminum is to be anodized is 5356 or 5856 Rod. Again, hidden welds if possible or minimal welds are preferred because even with these filler materials, a noticeably different shade in the weld area will be seen after anodizing.

Joints between large anodized panels should be interrupted with divider strips, shadow lines, or changes in plane or texture, rather than being treated as simple butt joints, to minimize variations in shade.

Assemblies which are to be anodized must have drainage holes provided, so that acid trapped in hollow areas can drain out and be properly flushed. Acid trapped in joints must also be thoroughly washed out. Otherwise, it will drain out after installation, causing objectionable stains.

When thick sheet is used for components which are to be anodized, and no grinding, polishing or buffing is required, a specialty sheet product should be specified, to minimize “structural streaking.” Specialty sheet is not generally recommended, however, if mechanical finishing is intended, but the finish in such cases should be sufficiently textured to conceal the “structural streaking.” If a textured finish is not acceptable, thicker specialty sheet can be used, provided extreme care is exercised during both the fabricating and finishing processes.

Composite structures consisting of wrought, cast, and welded aluminum will exhibit extreme ap-

pearance differences after anodizing due to their differing alloy composition and metallurgical structure. Aluminum that has been cold worked extensively, such as in tapered aluminum flagpoles and lighting support poles, can exhibit apparent color variation within a single alloy after anodizing. This color variation due to anodizing cold worked aluminum cannot be controlled. Anodizing should not be specified for composite or extensively cold worked structures when appearance differences are unacceptable.

In specifying color anodizing it must be recognized that each alloy produces its own characteristic shade, and specific colors can be provided only by certain alloys. The selection of alloys should be carefully specified and controlled, and not mixed indiscriminately.

For example, the ‘Duranodic’ process mentioned above requires either of four series of alloys to get the proper color: 1100, 5000, 6000, or 7000. However, mixing them together in a structure, and in some cases within the same alloy (i.e. 6061 & 6063), does not provide the same coloring on the entire weldment. All will shade differently when anodized together.

Specifications should include the requirement of color samples showing the color range to be expected in production of any specific color and shade.

With the exception of lead and titanium, other metals should not be included in assemblies to be anodized, as the anodizing process will dissolve them.

All surface protective coverings such as adhesive paper and strippable plastic films should be removed as soon as possible after installation because they can become brittle and unpeelable under exposure to sunlight and weather, and under these conditions they can cause staining.

For maintenance of anodic finishes ordinary wax cleaners, soap or mild detergents and water are generally satisfactory. DO NOT USE alkaline or acid materials. Some anodizers offer touch-up materials, in either spray or liquid form, to their customers.

Refer to AAMA 609/610-02, “Cleaning and Maintenance Guide for Architecturally Finished Aluminum.”

Quality of the seal can also be checked by the following ASTM and ISO (International Standards Organization) tests:

- *ASTM B 680, Test Method for Seal Quality of Anodic Coatings on Aluminum by Acid Dissolution.*
- *ISO 3210, Assessment of Sealing Quality by Measurement of the Loss of Mass after Immersion in Phosphoric Chromic Acid Solution.*
- *ASTM B 457, Test Method for Measurement of Impedance of Anodic Coatings on Aluminum.*
- *ISO 2931, Assessment of Quality of Sealed Anodic Oxide Coatings by Measurement of Admittance or Impedance.*

Recommendations of the proprietary process anodizers should be followed with regard to seal tests.

Guide Specifications and Inspection Methods

Four publications of the American Architectural Manufacturers Association (AAMA) are recommended as references for those who desire more detailed information or who require guidance on specifying and inspecting anodized finishes for architectural aluminum products. These publications are listed below:

- *AAMA 611-98, Voluntary Specification for Anodized Architectural Aluminum.*
- *AAMA 2603-02, Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels.*
- *AAMA 2604-02, Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels.*
- *AAMA 2605-02, Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.*

Care and Maintenance of Anodized Aluminum

(The material appearing in this section has been excerpted from AAMA "Care and Handling of Architectural Aluminum from Shop to Site," CW-10-97. See also, Chapter 5, Applied Coatings.)

General Considerations

Building owners and managers, along with the architects who have designed their buildings, have

always been concerned about the appearance of the exterior wall. The attractiveness of the wall design and the continued excellent appearance of a properly located building brings in and keeps satisfied tenants. The architect who has specified anodized aluminum wall and window components has done so first because of the beauty which can be achieved with such anodized finishes and second because of the long life, durability, and low maintenance that these finishes provide. It then becomes the responsibility of the building owner or manager to see that the original beauty of the building exterior is maintained in order to preserve the desirability and profitability of the property.

The American Architectural Manufacturers Association, recognizing the need for the aluminum industry to provide information on the care and maintenance of exterior wall finishes, released a publication titled "*Cleaning and Maintenance Guide for Architecturally Finished Aluminum, AAMA 609/610-02.*" This specification outlines methods, equipment, and materials to clean anodized aluminum after construction and for subsequent, periodic maintenance. The methods outlined are applicable to architectural products fabricated from both rolled and extruded shapes, including window and door frames, store fronts, and entrances, curtain walls, mullions, hand rails, flag poles, and hardware. The information provided in the specification is useful to building owners, managers, architects, contractors, and others in the building industry who are interested in the proper care and maintenance of anodized aluminum.

As with any finished building material, aluminum requires reasonable care prior to and during installation and periodic cleaning and maintenance after installation. Although anodized aluminum is exceptionally resistant to corrosion, discoloration and wear, its natural beauty can be marred by harsh chemicals, abuse, or neglect. Such conditions usually affect only the surface finish but do not reduce the service life of the aluminum. All exterior surfaces collect varying amounts of soil and dirt, depending on geographic area, environmental conditions, finish and location on the building. These factors and the owner's attitude regarding surface appearance determine the type and frequency of cleaning required. The aluminum cleaning schedule should be integrated with other cleaning schedules for efficiency and economy. For example, both the glass and the aluminum

curtain wall can be cleaned at the same time.

Cleaning may be required more often in one geographic area than another when appearance is of prime importance. More frequent cleaning will be required in heavy industrialized areas than in rural areas. Seasonal rainfall can affect washing frequency by removing water soluble deposits and less adherent soil. In foggy coastal regions, frequent cycles of condensation and drying can create a heavy buildup of atmospheric salts and dirt which can adhere tenaciously. In climates where the rainfall is low, the opportunity for atmospheric washing of the surface is minimal. Los Angeles, for example, with its unique combination of limited rainfall, temperature fluctuation, smog and condensation, requires that aluminum be cleaned more frequently than in other metropolitan areas with more frequent rainfall.

In both wet and dry climates, recessed and sheltered areas usually become more heavily soiled because of the lack of rain washing. More frequent and longer periods of condensation also occur in protected areas, increasing the adhesion of the soil. This is particularly true of soffit areas on overhangs, bottoms of fascia panels, sheltered column covers, and the like. Periodic maintenance inhibits long term accumulation of soil which, under certain conditions, can accelerate weathering of the finish.

Cleaning Procedures

Cleaning procedures for aluminum should be initiated as soon as practical after completion of installation to remove construction soils and accumulated environmental soils and discolorations.

Cleaning work should start at the top of the building and proceed to the ground level in a continuous drop. Using a forceful water spray, an area the width of the stage or scaffolding should be rinsed as cleaning proceeds from the top down.

Because surface soils can be light or heavy, several progressively stronger cleaning procedures can be employed depending on the severity and tenacity of the soil. Only trial and error testing can determine which will be most effective. The simplest procedure to remove the soil is the one which should be used.

For light soils, the simplest procedure is to flush the surface with water using moderate pressure. If soil is still present after air drying the surface, scrubbing with a brush or sponge and concurrent spraying

with water should be tried. If soils still adhere, then a mild detergent cleaner should be used with brushing or sponging. Washing should be done with uniform pressure, first horizontally then vertically. Following the washing, the surfaces must be thoroughly rinsed by spraying with clean water.

If it is necessary to remove oil, wax, polish, or other similar materials, methyl-ethyl-ketone (MEK) or an equivalent solvent is recommended for clean up. Extreme care must be exercised when solvents of this type are used since they can damage organic sealants, gaskets and finishes. These solvents should never be used on anodic finishes protected by clear organic coatings unless the organic coating has deteriorated and should be removed.

Removing heavy surface soils can require the use of an abrasive cleaning pad. In this procedure the pad is thoroughly soaked with clean water or a mild detergent cleaner and the metal surface is hand scrubbed with uniform pressure. Scrubbing action should be in the direction of the metal grain. Scrubbing with a nylon cleaning pad impregnated with a surface protectant material is also recommended for removing stubborn soils and stains. After scrubbing, the surface should be rinsed thoroughly with clean water to remove all residue. In some circumstances it is necessary to wipe the surface with a solvent. The surface is then permitted to air dry or is wiped dry with a chamois, squeegee or lint free cloth.

Power cleaning tools can be used to remove unusually heavy soils from large areas including panels and column covers. When using such tools, the surface must be continually flushed with clean water or a mild detergent cleaning solution to provide lubrication and a medium for carrying away the dirt. After an area has been machine scrubbed, it must be rinsed with clean water and thoroughly scrubbed with a fairly stiff bristle brush. The surface is then either air dried or wiped dry.

Inspection

It is suggested that the building owner or manager provide an engineer or other qualified representative to inspect the cleaning work. Care must be taken to see that metal seams, crevices, sills, and other areas that can trap water, cleaner, or dirt are carefully cleaned and dried. A final inspection to ensure that no discoloration or stains remain on the surface is recommended.

Cleaning Precautions

Certain precautions must be taken when cleaning anodized aluminum surfaces. Aluminum finishes must first be identified to select the appropriate cleaning method. Aggressive alkaline or acid cleaners must never be used. Cleaning hot, sun heated surfaces should be avoided since possible chemical reactions will be highly accelerated and cleaning non uniformity could occur. Strong organic solvents, while not affecting anodized aluminum, can extract stain producing chemicals from sealants and can affect the function of the sealants. Strong cleaners should not be used on window glass and other components where it is possible for the cleaner to come in contact with the aluminum. Excessive abrasive rubbing should not be used since it could damage the finish.

Field Protection and Maintenance

Field protection and maintenance of cleaned surfaces is of particular interest. A wipe-on surface protectant is now available which is estimated to provide protection for 12 to 24 months in the harshest environments. This protectant is applied to a thoroughly cleaned and dried anodized surface with a lint free cloth or felt pad. The benefits of such an application are twofold; first, it protects the finish, and second, it makes subsequent maintenance easier. Subsequent maintenance can be reduced to simply flushing the surface with water, permitting it to dry and wiping on a surface protectant every few years. In applying this protectant it is very important that the manufacturer's recommendations be carefully followed.

Equipment and Products

Equipment and products needed for cleaning and maintaining anodized aluminum finishes are listed in Section 7 of AAMA 609/610-02. These include mild soaps, detergents, non etching cleaners, abrasive cleaning pads and cleaning machines. AAMA, however, has not evaluated these materials nor does its listing constitute an endorsement. This list is included only as an aid to potential users in identifying the materials.

Many waxes are available for application to anodized finishes, but they are best used on interior items such as hand rails, doors, and decorative metals. It is generally not practical to use these materials on high rise portions of a building.

Care and Maintenance of Painted Aluminum

(The material appearing in this section has been excerpted from AAMA CW-10-97, Care and Handling of Architectural Aluminum from Shop to Site.)

General Considerations

Care and maintenance guidelines for anodized aluminum also apply to painted aluminum. The architect depends on the finish to provide the beauty in the building he has designed. The building owner and manager want to preserve this beauty thereby preserving the desirability and profitability of the property.

As in the case of anodized aluminum, the American Architectural Manufacturers Association released a publication *Cleaning and Maintenance Guide for Architecturally Finishes Aluminum*, AAMA 609/610-02. This guide outlines methods, equipment, and materials applicable for cleaning architecturally finished aluminum after construction and for subsequent periodic maintenance.

Organic aluminum coatings do not normally show an appreciable amount of dirt accumulation. In many atmospheres, dirt and soil would not be detrimental to the coating, but cleaning and surface care is desirable for the sake of appearance. In areas where heavy industrial deposits have dulled the surface, where materials from construction processes have soiled the surface; or where cleaner has run down from other surfaces, surface cleaning is desirable.

Climatic conditions affect the cleanliness of organic coatings in the same way they affect anodized coatings. In some areas rainfall can be sufficient to keep exterior surfaces looking clean and bright. In areas of low rainfall or in heavily industrialized areas, periodic cleaning will be necessary. This is also true of foggy coastal regions with frequent cycles of condensation and drying which can cause a build up of atmospheric salts and dirt. In any climate, sheltered areas under overhangs can become soiled from lack of rain washing. Cleaning painted aluminum components in the exterior wall may be scheduled along with cleaning the glass.

If automatic wall cleaning equipment is to be used on a building, a test should be made early in the equipment design to ensure that the cleaning solutions and brushes, as well as the frequency of cleaning, will have no detrimental effect on the coating.

Cleaning Procedures

Painted surfaces should be cleaned as soon as possible after installation to remove construction soils and accumulated environmental soils. Ideally, a forceful water rinse from the top down should be employed before applying any cleaner. Some type of surface agitation helps. A low volume of water at moderate pressure is better than a high volume at low pressure. Rubbing the surface with soft brushes, sponges or cloth during the rinsing also helps.

If a simple water rinse with brushing, sponging, or rubbing with a cloth is not sufficient to remove the soil, a mild detergent or mild soap will be necessary.

Washing with a mild detergent or mild soap should be done by brushing or sponging with a uniform pressure, first horizontally, then vertically. Following the washing, the surfaces must be thoroughly rinsed with clean water. If the cleaner has been permitted to dry, sponge the surfaces while rinsing, if necessary. Rinsed surfaces are permitted to air dry or wiped dry with a chamois, squeegee or lint free cloth.

Cleaner run down should be minimized and those areas subject to run down should be rinsed immediately, and as long as necessary, to lessen the probability of streaking.

Cleaning chemicals must not be allowed to collect on surfaces, to "puddle" on horizontal surfaces or to collect in joints and crevices. These surfaces, joints and crevices should be thoroughly flushed with water and dried.

Mild detergents and soaps, which are safe for bare hands, should be safe for coated aluminum. Stronger detergents, such as some dishwasher detergents, should be carefully spot tested. Some of the latter would necessitate using rubber gloves and long handled brushes. Some mild cleaning solutions are available for automatic building washing machines.

Mild solvents such as mineral spirits can be used to remove grease, sealant or caulking compounds. Stronger solvents or solvents containing cleaners can soften paints. To prevent damage to the finish, the coating manufacturer should be consulted and these types of solvent or emulsion cleaners should first be spot tested. Care should be taken to assure that no surface marring takes place in this manner since it could give an undesirable appearance at certain viewing angles. Cleaners of this type are usually

applied and removed with a clean cloth. Remaining residue should be washed with mild soap and rinsed with water. Use solvent cleaners sparingly.

Since solvents can extract materials from sealants which could stain the painted surface or could prove harmful to sealants, their possible effects must be considered. Test a small area first.

If cleaning heavy tenacious surface soil or stubborn stains has been postponed, a more aggressive cleaner and technique is required. Cleaner and technique should be matched to the soil and the painted finish. Some local manual cleaning may be needed at this point. Always follow the recommendations of the cleaner manufacturer as to proper cleaner and concentration. Test clean a small area first. Cleaners should not be used indiscriminately. Do not use excessive, abrasive rubbing since it can alter surface texture or impart a "shine" to the surface.

Dried concrete spillage on the painted surface can be quite stubborn to remove. Special cleaners and/or vigorous rubbing with non abrasive brushes or plastic scrapers may be necessary.

Diluted solutions of Muriatic Acid (under 10%) can be effective in removing dried concrete stains, and effective proprietary cleaners for concrete and mortar staining are available. However, a test area should be tried first, and proper handling precautions must be exercised for safety reasons.

Mixing cleaners **can be very dangerous**, as well as ineffective. For example, mixing chlorine containing materials such as bleaches, with other cleaning compounds containing ammonia, can produce poison gas.

Always rinse the surface after removing heavy surface soil.

Summary of Cleaning Tips

- Overcleaning or excessive rubbing can do more harm than good.
- Strong solvents (MEK for example) or strong cleaner concentrations can cause damage to painted surfaces.
- Avoid abrasive cleaners. Do not use household cleaners that contain abrasives on painted surfaces.
- Abrasive materials such as steel wool, abrasive brushes, etc., can wear and harm finishes.
- Avoid drips and splashes. Remove run downs as quickly as possible.

- Avoid temperature extremes. Heat accelerates chemical reactions and can evaporate water from solution. Extremely low temperature can give poor cleaning results. Cleaning under adverse conditions can result in streaking or staining. Ideally, cleaning should be done in shade at moderate temperature.
- Do not substitute a heavy duty cleaner for a frequently used, mild cleaner.
- Do not scour painted surfaces.
- Never use paint removers, aggressive alkaline, acid or abrasive cleaners. Do not use trisodium phosphate or highly alkaline or highly acid cleaners. Always do a test surface.
- Follow manufacturers recommendations for mixing and diluting cleaners.
- Never mix cleaners.
- To prevent marring, make sure cleaning sponges, cloth, etc., are grit free.
- “An ounce of prevention is worth a pound of cure.”
- In addition to the foregoing, consideration must be given to the effects run down can have on shrubbery, personnel, equipment and other

items located below. Such considerations can affect the timing in the cleaning schedule.

Inspection

It is suggested that the building owner or manager provide a qualified inspector to see that the cleaning operations are carried out in accordance with the recommended procedures.

Standard Finish Designations (as established by the Aluminum Association)

For many years, each of the prime producers of aluminum had his own system for identifying the many different finishes available. This resulted in a bewildering assortment of unrelated finish symbols, confusing to both architects and fabricators. Recognizing the necessity of correcting this situation, the Aluminum Association, in 1959, formed a committee representing all of the major producers, to study the problem and formulate an industry wide designation system acceptable to all.

The result was the Aluminum Association Finishes Designation System, adopted by the Association in 1963 and first published in 1964. Subsequent developments in anodizing processes,

Table 1-1: Finishes for Aluminum Hardware

Listed in this table are the Builders Hardware Manufacturers Association (BHMA) designations for finishes most commonly in use today on aluminum hardware. Since U.S. Finish Designations occasionally appear in specifications, the nearest U.S. equivalents of the BHMA code numbers are shown on the list. For a complete listing and descriptions of hardware finishes refer to *ANSI/BHMA A156.18, American National Standard for Materials and Finishes*.

Code No.	Description	Nearest US Equivalent
627	Satin aluminum, clear coated	US27
628	Satin aluminum, clear anodized	US28
666	Bright brass plated, clear coated	US3
667	Satin brass plated, clear coated	US4
668	Satin bronze plated, clear coated	US10
669	Bright nickel plated	US14
670	Satin nickel plated	US15
671	Flat black coated	US19
672	Bright chromium plated over nickel	US26
673	Aluminum clear coated	USP
688	Satin aluminum, gold anodized	US4

minor modifications, and several new designations have resulted in the current (revised) Designation System.

The Aluminum Association's Finish Designation System, as explained in the following discussion, is designed to cover all commonly used finishes, and provides also for accommodating new finishes as they are developed. The National Association of Architectural Metal Manufacturers endorses this system and recommends its consistent use not only by all of its member companies but by all those who are concerned with identifying and specifying aluminum finishes,

In this system, seven categories—the mechanical finishes, the chemical finishes, and five types of coatings—are designated by different letters as follows:

Mechanical Finishes	M
Chemical Finishes	C
(including conversion coatings)	
Anodic Coatings	A
Resinous and Other Organic Coatings....	R
Electroplated and Metallic Coatings	E
Vitreous Coatings	V
Laminated Coatings	L

Each of these categories in turn includes a variety of specific finishes bearing an identifying two digit number. The designation for any finish, then, consists of one of these seven letters followed by two digits. In the case of Protective and Decorative Anodic Coatings (Table 1-5) three digit numerals are used to further define them by minimum coating thickness and weight. To date, however, numbers have been assigned to only those finishes classified as Mechanical Finishes (Table 1-3), Chemical Finishes (Table 1-4) and Anodic Coatings (Table 1-5).

The method tentatively recommended for identifying other types of coating finish is explained in Table 1-2, which summarizes the system in its present form. It will be seen that designations have not yet been determined for many of the specific types of applied coatings. This matter is still under study, however, and it is anticipated that the sys-

tem will be extended to include at least the more common of these finishes.

The descriptions of finishes given under the heading "Examples of Methods of Finishing" in Tables 1-3, 1-4, and 1-5 are intended only as illustrations of appropriate methods and not as specifications. Alternatives to these methods of obtaining the finish are acceptable, provided that an equivalent finish is produced. There are many variations and limitations of both equipment and procedures in the finishing industry which require modifications of such suggested methods.

Explanation of the Use of the System

Where only a simple finish is called for, a single designation is used alone (e.g. M33), but more frequently two or more designations will be combined to form a composite designation identifying a sequence of operations leading to a final finish (e.g. C22A31).

When designations for chemical or applied finishes are used alone, it is to be understood that other processing steps normally used as preparation for the specified finish can be used at the option of the finisher. When a finish requires two or more treatments of the same class, the class letter should be repeated, followed in each case by the appropriate two digit numeral.

The use of the letter 'x' in all categories of the designation system (e.g. M1x, C2x, etc.) requires additional explanation. This symbol indicates that the Aluminum Association has not yet assigned any specific designations in the classification so designated; any finishes in these categories presently have no recognized numerical designation and must therefore be described in words.

The 'x' symbol is to be used by the specifier; he should not arbitrarily substitute a digit of his own selection in place of the "x."

The procedure to be followed where such finishes are concerned is illustrated in Examples 4 and 5 on page 1-17.

The examples on the following page illustrate the use of the system. Note that each designation is preceded by the letters AA to identify it as an Aluminum Association designation.

Hardware Finishes

Architectural hardware finishes are designated by code numbers established by the Builders Hardware Manufacturers Association (BHMA). The nearest US equivalents of BHMA numbers are listed in its standard *ANSI/BHMA A156.18-2000*. Samples of selected finishes are available from its New York office. The equivalent aluminum finishes are listed in Table 1-1.

Example 1 – Architectural Building Panel

To specify a matte anodized finish such as that produced by first etching the aluminum and then applying a durable clear anodic coating, the architect would use the designation

AA – C22A41, which represents:

C22 – Chemical Finish, Etched, Medium Matte (Table 4)

A42 – Anodic Coating, Architectural Class 1, clear coating 0.7 mil or thicker (Table 5)

Example 2 – Architectural Extrusion with Integral Color

If an architect wishes to specify an anodized finish with a non specular surface and an integral color, he uses the designation

AA – M12C22A42, of color to match approved sample.

These symbols represent:

M12 – Mechanical Finish, Non specular as fabricated (Table 3)

C22 – Chemical Finish, Medium Matte (Table 4)

A42 – Anodic Coating, Architectural Class 1, Integrally colored coating 0.7 mil or thicker (Table 5)

Example 3 – Extruded Assembly, Welded, with Integral Color

Because of the necessity of dressing down and blending the welded areas, a directional textured, rather than bright finish is usually specified in this case, though for some products concealed welding can be successfully used to join prefinished parts. The designation (for a directional finish) should be

AA – M32A42, of color to match approved sample. This calls for:

M32 – Mechanical Finish, Directional Textured, Medium Satin (Table 3)

A42 – As in Example 2 above

Example 4 – Etched Finish with Clear Lacquer Protection

Since clear lacquer is a type of organic coating and, as such, has no specific finish designation, the type to be used must be specified.

This finish, then, would be designated approximately as follows:

AA – C22R1x, using “ABC” Company’s clear methacrylate lacquer No. _____,
applied in two coats with interim drying, to a total thickness of 0.6 mils.
(C22 designates a medium matte etch).

Example 5 – Patterned Sheet with Organic Coating

In this case, both the pattern and the coating must be specified, and the designation would be

AA – M1xC41R1x, using “One” Company’s pattern No. _____ and
“Another” Company’s (brand) coating, _____
_____color, applied... (state requirements)....

(C41 designates acid chromate fluoride pretreatment)

TABLE 1-2 - SUMMARY OF STANDARD DESIGNATIONS FOR ALUMINUM FINISHES

All designations are to be preceded by the letters AA, to identify them as Aluminum Association designations.
Finishes printed in **boldface type** are those most frequently used for architectural work.

MECHANICAL FINISHES (M)			
As Fabricated	Buffed	Directional Textured	Non-Directional Textured
M10—Unspecified	M20—Unspecified	M30—Unspecified	M40—Unspecified
M11—Specular as fabricated	M21—Smooth specular	M31—Fine satin	M41—Extra fine matte
M12—Non-specular as fabricated	M22—Specular	M32—Medium satin	M42—Fine matte
M1x—Other	M2x—Other	M33—Coarse satin	M43—Medium matte
		M34—Hand rubbed	M44—Coarse matte
		M35—Brushed	M45—Fine shot blast
		M3x—Other	M46—Medium shot blast
			M47—Coarse shot blast
			M4x—Other
CHEMICAL FINISHES (C)			
Non-Etched Cleaned	Etched	Brightened	Chemical Conversion Coatings
C10—Unspecified	C20—Unspecified	C30—Unspecified	C40—Unspecified
C11—Degreased	C21—Fine matte	C31—Highly specular	C41—Acid chromate-fluoride
C12—Inhibited chemical cleaned	C22—Medium matte	C32—Diffuse bright	C42—Acid chromate fluoride-phosphate
C1x—Other	C23—Coarse matte	C33—Highly specular	C43—Alkaline chromate
	C24—Fine matte	C3x—Other	C44—Non-chromate
	C25—Adhesion pretreatment		C45—Non-rinsed chromate
	C26—Desmut		C46—Non-rinsed non-chromate
	C27—Desmut		C4x—Other
	C28—Etched designs		
	C2x—Other		
ANODIC COATINGS (A)			
General	Protective and Decorative	Architectural Class II	Architectural Class I
A10—Unspecified	A21*—Clear (natural)	A31—Clear (natural)	A41—Clear (natural)
A12—Chromic acid anodic	A22*—Integral color	A32—Integral color	A42—Integral color
A13—Hard, wear and abrasion resistant coatings	A23*—Impregnated color	A33—Impregnated color	A43—Impregnated color
A14—Nonchromate adhesion pretreatment	A24—Electrolytically deposited color	A34—Electrolytically deposited color	A44—Electrolytically deposited color
A1x—Other	A2x—Other	A3x—Other	A4x—Other

*Third digit (1, 2 or 3) added to designate min. thickness in 1/10 mils. See TABLE 1-5.

ELECTROPLATED (E)

E10—Unspecified

E1x—Specified

ORGANIC COATINGS (R), VITREOUS COATINGS (V), and LAMINATED COATINGS (L)

The following designations can be used until more complete systems are developed.

Resinous and Organic

R10—Unspecified

R1x—To be specified

Vitreous – Porcelain and Ceramic Types

V10—Unspecified

V1x—To be specified

Laminated

L10—Unspecified

L1x—To be specified

TABLE 1-3 - STANDARD DESIGNATIONS FOR MECHANICAL FINISHES

All designations are to be preceded by the letters AA, to identify them as Aluminum Association designations.

Type of Finish	Designation	Description	Examples of Method of Finishing
AS FABRICATED	M 10	Unspecified	
	M 11	Specular as fabricated	
	M 12	Non-specular as fabricated	
	M 1x	Other	To be specified.
BUFFED	M20	Unspecified	Optional with finisher.
	M21	Smooth specular	Polishing with grits coarser than 320 and finishing with 320 grit, using peripheral wheel speed of 6,000 fpm (30 m/s). Then buffing with tripoli based buffing compound, using peripheral wheel speed of 7,000 (36 m/s) to 8,000 fpm (41 m/s).
	M22	Specular	Buffing with tripoli compound, using peripheral wheel speed 7,000 (36 m/s) to 8,000 fpm (41 m/s).
	M2x	Other	To be specified.
DIRECTIONAL TEXTURED	M30	Unspecified	Optional with finisher.
	M31	Fine satin	Wheel or belt polishing with aluminum oxide grit of 320 to 400 size, using peripheral wheel speed of 6,000 fpm (30 m/s).
	M32	Medium satin	Wheel or belt polishing with aluminum oxide grit of 180 to 220 size, using peripheral wheel speed of 6,000 fpm (30 m/s).
	M33	Coarse satin	Wheel or belt polishing with aluminum oxide grit of 80 to 100 size; peripheral wheel speed of 6,000 fpm (30 m/s).
	M34	Hand rubbed	Hand rubbing with stainless steel wool lubricated with neutral soap solution. Final rubbing with No. 00 wool.
	M35	Brushed	Brushing with rotary stainless steel wire brush, wire diameter 0.0095 in. (0.24 mm); peripheral wheel speed 6,000 fpm (30 m/s) or various proprietary satin finishing wheels or satin finishing compounds with buffs.
	M3x	Other	To be specified.
NON-DIRECTIONAL TEXTURED	M40	Unspecified	Optional with finisher.
	M41	Extra fine matte	Air blasting with 200-mesh washed silica sand or aluminum oxide, using 45 psi (310kPa) pressure with gun held 8-12 inches (203-305 mm) from work at 90° angle.
	M42	Fine matte	Air blasting with 100 to 200-mesh silica sand or aluminum oxide. Air pressure 30 to 90 psi (207 to 621 kPa), depending on metal thickness; gun held 12 in. (305 mm) from work at angle of 60° to 90°.
	M43	Medium matte	Air blasting with 40 to 80-mesh silica sand or aluminum oxide. Air pressure 30 to 90 psi (207 to 621 kPa), depending on metal thickness; gun held 12 in. (305 mm) from work at angle of 60° to 90°.
	M44	Coarse matte	Air blasting with 16 to 20-mesh silica sand or aluminum oxide. Air pressure 30 to 90 psi (207 to 621 kPa), depending on metal thickness; gun held 12 " (305 mm) from work at angle of 60° to 90°.
	M45	Fine shot blast	Cast steel shot of ASTM size 70-170 applied by air blast or centrifugal force.
	M46	Medium shot blast	Cast steel shot of ASTM size 230-550 applied by air blast or centrifugal force.
	M47	Coarse shot blast	Cast steel shot of ASTM size 660-1320 applied by air blast or centrifugal force.
	M4x	Other	To be specified.

TABLE 1-4 - STANDARD DESIGNATIONS FOR CHEMICAL FINISHES

All designations are to be preceded by the letters AA, to identify them as Aluminum Association designations.

Type of Finish	Designation	Description	Examples of Method of Finishing
NON-ETCHED CLEANED	C10	Unspecified	Optional with finisher.
	C11	Degreased	Organic solvent using petroleum-based or chlorinated solvents.
	C12	Inhibited chemically	Inhibited chemical type cleaner, 4-6 oz/gal (30-45 g/L), used at 140-180°F. Cleaned(60-80°C) for 2 – 5 min with a pH between 4.5 to 8.5.
	C1x	Other	To be specified.
ETCHED	C20	Unspecified	Optional with finisher.
	C21	Fine matte	Tri-sodium phosphate, 3-6 oz/gal (22-45 g/L), used at 140°-160°F (60°-80°C) for 3-5 minutes.
	C22	Medium matte	Sodium hydroxide (caustic soda) 4-6 oz/gal (30-45 g/L), used at 130°-150°F (49°-66°C) for 5-10 minutes.
	C23	Coarse matte	Sodium fluoride, 1.5oz (11g), plus sodium hydroxide 4-6 oz/gal (30-45 g/L), used at 130°-150°F (54°-66°C) for 5-10 minutes.
	C24	Fine matte	Nitric Acid (25% vol) and hydrofluoric acid (1% vol) used at room temperature for 5 to 10 min.
	C25	Adhesion pretreatment	Sulfuric acid (98%) at 16.3% vol and 6% (wt) sodium dichromate with 0.25 oz/gal (1.9 g/L) of 2024 aluminum dissolved used at 140°-158°F (60°-70°C) for 9 to 30 min.
	C26	Desmut	Nitric acid, 25-50% by vol used at room temperature for 1-6 min (hydrofluoric acid can be added [1-5% vol]).
	C27	Desmut	Chromic acid, 13.35 oz/gal (100 g/L) plus sulfuric acid, 8 oz/gal (60 g/L) plus ammonium bifluoride 0.4 – 0.67 oz/gal (3-5g/L) used at ambient temperature for 1 to 6 min.
	C28	Etched designs	Ferric chloride (42% Be), 50% (vol) used at room temperature.
	C2x	Other	To be specified.
BRIGHTENED	C30	Unspecified	Optional with finisher.
	C31	Highly specular	Immersed in 73-83% (vol) phosphoric acid and 2-5% (vol) nitric acid (and additions of 0.01% copper and 10-12% aluminum phosphate) at 194°F (90°C) for 15 sec to 5 min.
	C32	Diffuse bright	Etched finish C22 followed by brightened finish C31.
	C33	Highly specular	Immersed in 15% phosphoric acid, 70% sulfuric acid used at 185°F (85°C) for 20 min with an applied current density of 140 asf (15 A/dm ²).
	C3x	Other	To be specified.
CHEMICAL COATINGS	C40	Unspecified	Optional with finisher.
	C41	Acid chromate-fluoride	Proprietary chemicals treatments of the following general makeup used producing clear to typically yellow colored surfaces – chromic acid (3.4 - 4.0 g/L) plus sodium dichromate (3.0 – 3.5 g/L) plus sodium fluoride (0.8 g/L) used at 86°F (30°C) for 3 min.
	C42	Acid chromate-fluoride-Phosphate	Proprietary chemical treatments of the following general makeup used producing clear to typically green colored surfaces – phosphoric acid (75%), 24 g/L plus sodium fluoride, 5 g/L plus chromic acid, 6.8 g/L.
	C43	Alkaline chromate	Proprietary chemical treatments used producing clear to typically gray colored surfaces
	C44	Non-chromate	Proprietary chemical treatments of the following general makeup, using no chromates. Example 1: Potassium fluozirconate (K ₂ ZrF ₄), 0.4 g/L plus ortho-boric acid (H ₃ BO ₃), 5.0 g/L plus potassium nitrate, KNO ₃ , 10 g/L plus nitric acid (HNO ₃), 0.4 mL used at 50° – 65°C for 5 to 15 min. Example 2: Zinc oxide, 10.2% wt plus nickel oxide, 1.85% plus phosphoric acid (75%), 44.3% plus nitric acid, 4.5% plus hydrofluoric acid (70%), 0.97% plus fluorosilic acid (35%), 4.2% used at 50°-65°C for 5 to 15 min.
	C45	Non-rinsed chromate	Proprietary chemical treatments in which coating liquid is dried on the work with no subsequent water rinsing.
	C46	Non-rinsed non-chromate	Proprietary chemical treatment in which coating liquid is dried on the work with no subsequent water rinsing.
	C4x	Other	To be specified.

TABLE 1-5 - STANDARD DESIGNATIONS FOR ANODIC COATINGS

All designations are to be preceded by the letters AA, to identify them as Aluminum Association designations.

Type of Finish	Designation	Description	Examples of Method of Finishing
GENERAL	A10	Unspecified	Optional with finisher.
	A11	Preparation for other applied coatings	0.1 mil (3um) anodic coating produced in 15% H ₂ SO ₄ used at 70° ± 2°F, (21° ± 1°C) 12 amp/sq ft (129 A/m ²) for 7 minutes, or equivalent.
	A12	Chromic acid anodizing coatings	To be specified. Example 1: chromic acid (2.5 – 3%) at 40°C at 0.1 – 0.5 A/dm ² for 5 to 30 min to produce a 2 - 15 um (0.1 – 0.6 mil) coating.
	A13	Hard, wear and abrasion resistant coatings	To be specified. Example 1: sulfuric acid (130 g/L) plus oxalic acid (14 g/L) used at 48 – 52°F at 36 asf for 20 min to produce a 1 mil coating.
	A14	Non-chromate adhesion pretreatment	To be specified. Example 1: Phosphoric acid (10%) used at 23 - 25°C at 10-12 V for 20 to 30 min to produce a 1-2 um (<0.1 mil) coating.
	A1x	Other	To be specified.
PROTECTIVE AND DECORATIVE (Coatings less than 0.4 mil thickness)	A21	Clear coating	Coating thickness to be specified. 15% H ₂ SO ₄ used at 70° ± 2°F (21° ± 1°C), 12 amp/sq ft (129 A/m ²).
	A211	Clear coating	Coating thickness - 0.1 mil (3um) minimum. Coating weight - 4 mg/in ² (6.2 g/m ²) min.
	A212	Clear coating	Coating thickness - 0.2 mil (5um) minimum. Coating weight - 8 mg/in ² (12.4 g/m ²) min.
	A213	Clear coating	Coating thickness - 0.3 mil (8um) minimum. Coating weight -12 mg/in ² (18.6 g/m ²) min.
	A22	Coating with integral color	Coating thickness to be specified. Color dependent on alloy and process methods.
	A221	Coating with integral color	Coating thickness - 0.1 mil (3um) minimum; Coating weight - 4 mg/in ² (6.2 g/m ²) min.
	A222	Coating with integral color	Coating thickness - 0.2 mil (5um) minimum; Coating weight - 8 mg/in ² (12.4 g/m ²) min.
	A223	Coating with integral color	Coating thickness - 0.3 mil (8um) minimum; Coating weight - 12 mg/in ² (18.6 g/m ²) min.
	A23	Coating with impregnated color	Coating thickness to be specified. 15% H ₂ SO ₄ used at 70° ± 2°F (21° ± 1°C), 12 amp/sq ft (129 A/m ²) followed by dyeing with organic or inorganic colors.
	A231	Coating with impregnated color	Coating thickness - 0.1 mil (3um) minimum; Coating weight - 4 mg/in ² (6.2 g/m ²) min.
	A232	Coating with impregnated color	Coating thickness - 0.2 mil minimum; weight - 8 mg/in ² (12.4 g/m ²) min.
	A233	Coating with impregnated color	Coating thickness - 0.3 mil minimum; weight - 12 mg/in ² (18.6 g/m ²) min.
	A24	Coating with electrolytically deposited color	Coating thickness to be specified. Application of the anodic coating, followed by electrolytic deposition of inorganic pigment in coating.
	A2	Other	To be specified.
ARCHITECTURAL CLASS II (Coatings with 0.4 to 0.7 mil thickness)	A31	Clear (natural)	15% H ₂ SO ₄ used at 70° ± 2°F (21° ± 1°C), 12 amp/sq ft (129 A/m ²) for 30 min, or equivalent.
	A32	Coating with integral color	Color dependent on alloy and anodic process.
	A33	Coating with impregnated color	15% H ₂ SO ₄ used at 70° ± 2°F (21° ± 1°C), 12 amp/sq ft (129 A/m ²) for 30 min, followed by dyeing with organic or inorganic colors.
	A34	Coating with electrolytically deposited color	Application of the anodic coating, followed by electrolytic deposition of inorganic pigment in coating.
	A3x	Other	To be specified.
ARCHITECTURAL CLASS I (Coatings of 0.7 mil or greater)	A41	Clear (natural)	15% H ₂ SO ₄ used at 70° ± 2°F (21° ± 1°C), 12 amp/sq ft (129 A/m ²) for 60 min, or equivalent.
	A42	Coating with integral color	Color dependent on alloy and anodic process.
	A43	Coating with impregnated color	15% H ₂ SO ₄ used at 70° ± 2°F (21° ± 1°C), 12 amp/sq ft (129 A/m ²) for 60 min, followed by dyeing with organic or inorganic colors.
	A44	Coating with electrolytically deposited color	Application of the anodic coating, followed by electrolytic deposition of inorganic pigment in coating.
	A4X	Other	To be specified.

REFERENCES

For more detailed information on the subject of finishes for aluminum the following references can be contacted for their publications:

Aluminum Anodizers Council (AAC), 1000 North Rand Road, Suite 214, Wauconda, Illinois 60084.

The Aluminum Association (AA), 900 19th Street, NW, Washington, DC 20006; www.aluminum.org.

Aluminum Company of America (ALCOA), 201 Isabella Street, Pittsburgh, PA. 15212 Technical Center, 100 Technical Drive, Alcoa Center, PA 15069; www.alcoa.com.

American Architectural Manufacturers Association (AAMA), 1827 Walden Office Square, Schaumburg, IL 60173; www.aamanet.org.

American Society for Metals (ASM International), 9639 Kinsman Road, Materials Park, OH 44073-0002; www.asm-intl.org.

Architectural Metals, L William Zahner, John Wiley and Sons, New York, NY.

Builders Hardware Manufacturers Association (BHMA), 355 Lexington Avenue, 17th Floor, New York, NY 10017; www.buildershardware.com.

Electroplating Engineering Handbook, Van Nostrand Reinhold Publishing Corp., New York, NY.

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FINISHES FOR THE COPPER ALLOYS

General

Among the architectural metals, the copper alloys are unique in that they are the only ones possessing integral color. Natural colors vary, depending on the alloy used, ranging from the salmon pink of alloy 110 (copper), through the golden yellows of alloys 385 (Extruded Architectural Bronze), 280 (Muntz Metal) and 230 (Red Brass) to the warm whites of the nickel silvers. The natural color range is augmented by the effects of weathering; patinas or verdigris on antiques; and statuary or oxidized finishes achieved either by exposure to the elements or by accelerated means.

Originally the term “bronze” was applied only to copper-tin alloys, and the term “brass” to alloys of copper and zinc, but this distinction no longer holds. There is now no definite dividing line between these two general classes of the copper-base alloys.

Architects and architectural metal fabricators in common have, for years, referred to the principal architectural alloys of copper as “bronzes” despite the fact that of the five principal alloys so used, none contain tin and three of them, in fact, are true brasses. There is some justification for this, however, since the alloys 230 (Red Brass), 280 (Muntz Metal) and 385 (Extruded Architectural Bronze) do resemble tin bronze architectural castings in color, in both the natural and weathered states.

In the natural finish they are dubbed simply “yellow bronze”; in the intermediate brown weathered states, “statuary bronze”; and in the final weathered or patinated condition, “green bronze”. Similarly, the nickel silver alloys are often referred to as “white bronze”. In the acknowledgement of this long established custom, therefore, the term “bronze” will generally be used to designate all of these alloys, with the realization that two, three, or even more distinct alloys are frequently required in order to complete a given architectural composition. The common finishes for “bronze” are listed on page 2-3.

Just as with aluminum, many of the finishes listed in the preceding Summary are, as indicated, sup-

plied by processors or product manufacturers, rather than by the prime producers of the metal. The only true end-use finishes supplied at the mill, for architectural work, are the “As Fabricated” finishes; all of the others are referred to as process finishes, being supplied after the metal leaves the mill.

Fastener alloys generally used are 220 (Commercial Bronze, 90%) and 260 (Cartridge Brass, 70%). A Unified Numbering System (UNS) for metals and alloys developed by ASTM and SAE has been applied to copper alloys and is administered by CDA. To utilize the UNS system, simply prefix the present CDA alloy numbers by the letter C and add a suffix 00. Thus, for example, copper alloy No.385 becomes C38500 in the UNS system.

Mechanical Finishes

Mechanical finishes are those that involve the use of no chemical or electrochemical treatment and no additive, but provide a surface texture by mechanical means alone. These textures vary widely in character and range from the surface appearance resulting from the various production processes to highly reflective surfaces produced by successive grinding, polishing and buffing operations. Costs vary in proportion to the amount of processing required.

“As Fabricated” Finishes

The term “As Fabricated” refers either to the metal stock or to a fabricated product. As a finish designation for copper alloy stock it refers to the surface appearance and texture imparted to the metal by the rolling mill, extrusion press, or casting mold that shapes it. Subsequent fabrication operations on the copper alloy, such as forming, sawing, punching, drilling, milling, etc., including scratches, can mar the “as fabricated” finish. Under some conditions the marring can be corrected by simple mechanical deburring and smoothing. For other conditions the marring can result in an unacceptable “as fabricated” mechanical finish, and a subsequent finishing operation will be required and should be specified.

Summary of Typical Copper Alloy Finishes

Finish	Copper Development Ass'n Finish Designation (see page 2-11)	Finish Normally Supplied By			Relative Costs (on flat surfaces)
		Mill	Process- sor	Fabricator or Finisher	
MECHANICAL					
As Fabricated	M10 Series	X			base
Buffed	M20 Series			X	medium to high
Directional Textured	M30 Series			X	low to medium
Non-Directional Textured	M40 Series			X	medium
Patterned	M4x (Specify)	X	X		low to medium ¹
CHEMICAL					
Cleaned only	C10 Series	X		X	base or low ²
Matte Dipped		X			base or low ²
Bright Dipped		X			base or low ²
Conversion Coatings	C50 Series			X	medium to high
COATINGS (see <i>Applied Coatings, Chapter 5</i>)					
Organic: Air Dry	060 Series			X	low to medium
Thermo-set	070 Series			X	low to medium
Chemical Cure	080 Series			X	low to medium
Vitreous			X		high
Laminated	L90 Series		X		medium to high
Metallic			X		medium to high

The term PROCESSOR, as used here, refers to a "middleman" between the mill and the fabricator, who applies coatings, textures or other finishes to metal bulk form, generally cut sheet or strip or coil stock. FABRICATOR refers to the producer of stock metal shapes or the manufacturer of the end-use product. He either provides the final finish or sends the fabricated product to a finisher who does this work. The FINISHER does not usually fabricate products but provides finishes, as specified, to products fabricated by others.

The RELATIVE COSTS indicated are necessarily approximate, for general guidance only. Exact costs vary considerably with quantity, type of product, method of application, quality of work, and other influences, and should always be verified.

¹ Certain embossed patterns, because of their stiffening effect, permit the use of thinner metal; and this saving can, in some cases, offset their cost. In other cases, patterned finishes involve extra costs.

² Pricing practice for these finishes varies with different prime producers.

"As Fabricated" mechanical finishes, as a class, are the simplest and least expensive obtainable. Such finishes can be quite acceptable for architectural applications and are widely used. Typical of these are specular "as fabricated" cold-rolled sheet and non-specular "as fabricated" extrusions. Highly polished rolls used at the mill for the final pass provide the specular finish on the cold rolled sheet. Carefully machined and well-maintained dies for the extrusion press ensure extruded surfaces free of objectionable die marks or striations.

These finishes vary somewhat, according to the metal-forming process used. Hot-rolled and heat-treated products have a comparatively dull surface finish and show a certain amount of darkening or discoloration, while cold-rolled surfaces have a brighter and more metallic color. Extruded products have an intermediate appearance somewhat resembling that of the cold-rolled items, and can have detectable surface striations caused by the extrusion die, while castings have a rougher matte finish.

The following are the typical variations of the "As Fabricated" finish:

- a) **Unspecified:** This is the uncontrolled natural finish produced by extrusion, casting, hot-rolling, or cold-rolling with unpolished rolls. On rolled products it can vary from dull to rather bright and have stains or light films of rolling oil.
- b) **Specular:** A mirror-like cold-rolled finish, produced on one or both sides of the sheet by final passing through highly polished steel rolls.
- c) **Matte:** A dull finish produced by hot-rolling, extruding, casting or cold-rolling, followed by annealing.

Polished / Buffed Finishes

These are process finishes, applied by the product manufacturer, and are produced by successive processes of grinding, polishing, and buffing. Because they require a series of operations, they are more expensive than other mechanical finishes, their cost generally being proportional to