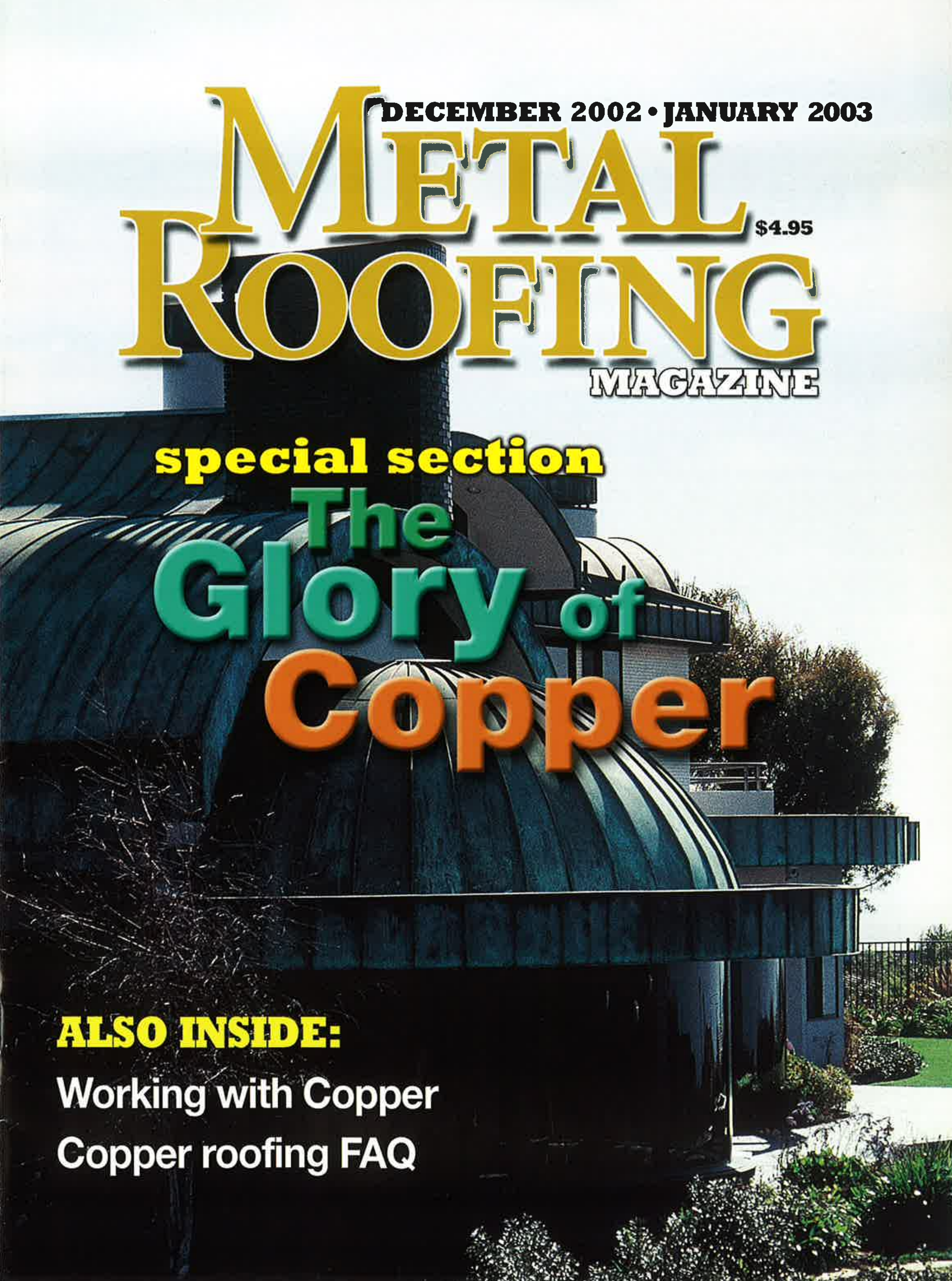

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METAL ROOFING MAGAZINE

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special section
The Glory of Copper

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Copper roofing FAQ

The GLORY of COPPER

No-nonsense choice or show-off? Well, both. But the Rolls Royce of roofing materials is cropping up on more than just churches these days.

When Jefferson County, Colo., built its Belmar Library last year, the copper roof got two kinds of comments. "People either said 'wow' or 'how could you spend so much money on this?'" says the county's Lisa VanderHaven. Six taxpayers felt strongly enough to write in. "We explained our value engineering, the longevity, and lower maintenance costs, and they all came around," says VanderHaven.

Few would dispute the "wow" of copper. "It's a living material," says architect Hank Smith, who put it on his own home. "It ages gracefully with the building. There's nothing like it."

And copper's durability is legendary. Whether it turns green or not, the metal forms a tough oxide/sulfate coating that resists corrosion almost indefinitely. Tests recently conducted on copper roofs in Europe from the 18th century showed that in theory, a copper roof could last a thousand years. As for the seams and details, copper's workability, malleability, and solderability mean that, in the right hands, it can be a roof with no weak points.

Few roofers will begrudge copper its status as the premier roofing material, but most think of it as a costly, specialty material, affordable only for roofs of public buildings and churches.But can copper really be an economical roof?

Copper prices spiked in the mid-1990s, and were high in the late 1980s, according to the Copper Study Group. But prices are currently about one-fourth of their peak, and near historic lows. "It's been low for five or six years," says copper roofer Charles Rieben of Lawrence Rieben & Sons. "Installation's the same cost as steel, so I can install a copper roof for one dollar a square foot more than Kynar."

Metal roofers are used to speaking in terms of life cycle costs, and with copper the cycle just needs extending a few decades to be the most cost-effective roofing material. A recent European study commissioned by the copper industry compared roofing costs of copper with an array of other metals, concrete and clay tiles, slate, and bitumen. The study concluded that "In the medium to long term (for lives of 60 to 80 years and 100 year and over), copper along with stainless steel proved to be the most cost-effective roofing materials of all those examined."

Copper's life cycle costs are further reduced by its

This Southern California home was built a dozen years ago, but its unique domes, barrel vaults, and S-curves make it one of the most memorable residential applications of copper. It was designed by Los Angeles achitect Marshall Lewis, known for his use of stone and copper. Eamon Kelly of H&K Roofing fabricated and installed the 2-piece T-panel using a New Tech panformer and seam cover and curving machines from Roll Former. The 16-oz. copper was supplied by Custom-Bilt Metals in El Monte, Calif., and was chemically patinated after installation. At right, the Beth Tfiloh Synagogue in Baltimore glistens with iridescent purples and reds not long after installation. PHOTOS: LEFT, MARCIA REED; RIGHT, CDA

Lead-coated copper weathers to a flat pewter look that perfectly suits certain architectural styles and colors — like this North Carolina beach home. PICKARD PHOTO

salvage value. Used copper retains much of its primary value, so unlike steel, recycling it isn't just a good deed. And new coil and sheet has up to 75 percent recycled content, so it's a genuinely "green" building material.

In America, of course, the "medium term" isn't 60 to 80 years; it's more like 30 years. Disposable roofs are the norm, and even homes and buildings have short lifespans. Beyond its aesthetic virtues, copper's primary appeal will always be to institutions (or the rare building or homeowner) planning in terms of 50-plus years.

Of course, many designers work with copper primarily for its beauty. Its most famous trait is its color display: the slow-moving fireworks of metal turning from bright to iridescent to brown to near black, then (usually) slowly on to the greenish verdigris patinas. Copper lovers come up with all kinds of words to describe just the array of browns: russet, chocolate, plum, mahogany, ebony.

While initial weathering can be extremely uneven, and can involve not only mismatched browns but also iridescent colors, studies have shown that virtually all irregularities even out after nine months.

For many, copper's natural weathering is part of its charm, as the metal struggles to find its equilibrium in its environment. In many arid regions, the material never turns green; patinated copper in the inland arid West is, for the most part, a contrivance. "I want the copper to be true to itself," says Dave Anderson, whose Belmar Library will probably remain dark for decades. "It looks great right now. It has a mahogany hue, almost like old leather. It has real character."

So it's surprising how many copper roofs get splashed with chemicals to turn them green in minutes. Southern California roofer Eamon Kelly says that of the many dozens of copper roofs he installed, all but two were artificially patinated. But then, who in this country has the patience to wait a couple years, much less 20 to 30 for a full patina? (See page 35)

One downside of copper is its propensity to stain light-colored materials such as stucco and stone. Patina-caused staining of surfaces is easily avoided by careful planning of gutters.

Staining was the reason behind the development of lead-coated copper in the early 20th century. The lead does not protect the copper — if anything, scratches in the lead surface can actually facilitate copper's corrosion, due to reverse galvanic action. But lead weathers to a flat, pewter color that has kept it going on rooftops for decades.

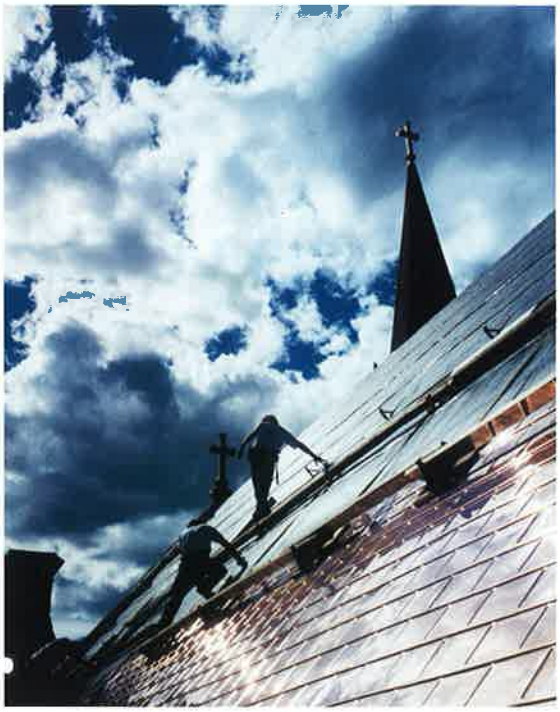
While no studies have indicated that the runoff from lead-coated copper roofs is unhealthful, concerns about the toxin led Revere Copper to begin offering copper coated in the zinc-tin ZT Alloy made by Follansbee Steel. Marketed as Freedom Gray, the material is said to have similar appearance and workability.

Architectural copper, in short, can show a lot of different faces: silver, brown, black, patina green, and artificially patinated turquoise, purple, and a host of other colors. For those who want copper to stay its original bright color, there are some preparations that make it possible, but they require frequent maintenance.

And copper can be painted as well. But just because something's possible doesn't mean it's right. ■

It looks nice on bay windows, but copper has shown up on some massive roofs too. The largest, we think, is still the World Headquarters of Domino's Pizza in Ann Arbor, Mich., built 1985-89. Designed by architect Gunnar Birkerts for Domino's founder Thomas Monaghan. The 1.2 million sq. ft. building was carefully detailed with low-sloping gables, long horizontal lines, and other touches associated with Frank Lloyd Wright, a hero of Monaghan's. Birkerts used the only metal system Wright ever used: copper — though he wisely stayed away from Wright's prefered profile, the Bermuda panel. The roof was site fabricated by Steyer Roofing Company, Detroit, in an Ultra Seam profile. CDA PHOTO

Craftsman's Dream, Roofer's Challenge



There's something special about copper projects. Rerroofing this 1901 church in Billings, Mont., with Revere's Bennington copper shingle got Bradford Roofing more comments than any other project. "It was a civic event," says Tom Bradford. BRADFORD ROOFING PHOTO

Experienced roofers seem to love copper, even as they point out the difficulties it can pose. "You have to be more careful with copper," says Eamon Kelly, whose Southern California company worked in both steel and copper until his retirement last year. "The panels aren't as stiff as steel, so you need more bodies on the job to handle the long ones. And if one bends, you're losing more money per square foot." Still, he loves the material, and fought to get the copper jobs: "When we got into copper, it made going to work every day great."

At the other end of the continent, Ray Magliozzi of Riverside Sheet Metal in Medford, Mass., expresses almost identical sentiments: "Copper can be a pain: it's soft, it dents easy, you can get fingerprints on it. You have to finesse it, take your time; if you don't treat it right, you can hurt it." At the same time, he continues, "You can bang it, kick it, scratch it, and it still looks good. It's friendlier, more forgiving, easy to work with, to hammer or curve. And if you make a hole in it, you can solder a patch on it."

It's copper's malleability, workability, and ability to forgive mistakes that installers love. It can be soldered and otherwise worked into watertight designs without the benefit of caulk or gaskets, creating a roof with virtually no weak points. But it can be an expensive material to experiment with.

Copper can be rolled into almost any form of metal roof, including snap-lock, nail strip, and snap-on batten, but traditionally, three styles predominate: double-lock standing seam, batten seam, Bermuda style (horizontal batten), and flat-lock. With the simplicity of these panel styles, a greater amount of site forming takes place with copper than with other metals.

Some roofers use mechanical seamers, some hand seamers, and most a combination of the two. Copper forgives most scratches, and even oil canning is less apparent on dull, weathered copper. Below: Copper installers tend to use more precise details that other roofers never learned, like this pinch-seam transition detail on a home in Montana. PHOTOS, FROM TOP: PICKARD ROOFING; METALCRAFTS; MIKE WINTERS ROOFING

Some basic facts for the copper novice:

• Copper's thermal coefficient of expansion is greater than steel's but less than that of aluminum: about 1/8 in. over 10 ft. for every 100 degrees F. Although older roofs didn't use them, the Copper Development Association now recommends that panels longer than 10 ft. be fitted with expansion clips.

At left: Initial weathering can be swift and uneven, sometimes depending on undetectable factors such as mill lubricants. Fear not: it all evens out in about a year, studies show. Center, handling coils for site roll forming. At right, a traditional batten seam installation on a North Carolina church. PHOTOS: LEFT, SHANE JOHNSON; CENTER AND RIGHT, PICKARD ROOFING

• As a dark material, copper absorbs a lot of solar heat, and transmits it to underlayments. Self-adhering ice and water barriers used in valleys and eaves should normally be rated to withstand high temperatures.

• Copper is a noble metal, and will corrode metals lower on the galvanic scale when they're in contact in the presence of an electrolyte — i.e., water. Aluminum flashings and galvanized fasteners are no-no's. Runoff from copper will also corrode aluminum guttering.

• Although 16-oz., 1/8 hard copper is generally used for roofs, valleys should be fitted with 20 oz. material to stand up to the frequent washes.

• Rosin paper is recommended between felt underlayment and copper, primarily to prevent adhesion. ■

A Copper Roofing FAQ

Long-pan expansion, wind uplift, and line corrosion

BY DANIEL STERNTHAL
NATIONAL PROGRAM MANAGER - ARCHITECTURAL APPLICATIONS
COPPER DEVELOPMENT ASSOCIATION

The Copper Development Association has introduced the design and construction community to the world of architectural copper via its Copper in Architecture Seminar Program. This program has allowed CDA to maintain contact with many architects, engineers, specifiers, and contractors. As a result of thousands of such presentations, CDA staff has responded to many design and construction questions.

The following is a sampling of the most common questions raised on copper in architecture. Many of the details accompanying this article come from CDA's *Copper in Architecture - Design Handbook.*

Long Pan Panels Design

One of the most complicated design issues CDA is asked for assistance with is the proper design and installation techniques for Long-Pan Roof Systems. The issues encompass roof pan length vs. seam length, cleat design and spacing, as well as the physical expansion characteristics of copper sheets.

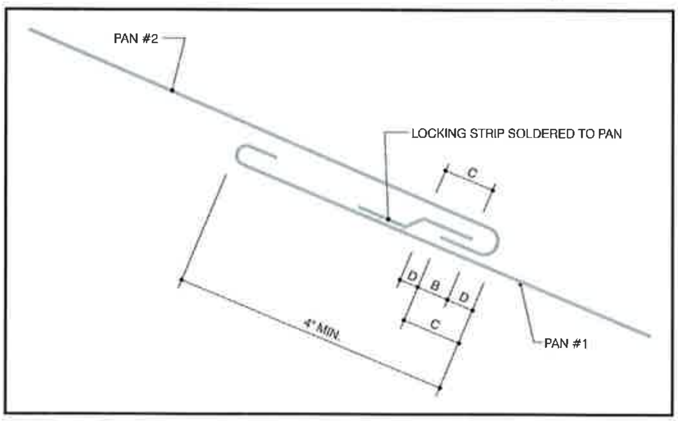
Historical details and installation procedures have recommended the installation of continuous roof seam lengths up to 30 ft. utilizing fixed cleats. For seam lengths exceeding 30 ft., the recommendation has been to utilize expansion cleats. See Detail B for cleat types.

Although such recommended techniques have proven effective, contemporary building design and construction practices require a more careful approach. Insulated roof systems (potentially leading to higher roof temperatures) and lightweight roof decks (leading to higher differential movement of building components) require more careful analysis and design. Upon reviewing historical and contemporary design and installation techniques, CDA has adopted an updated approach and is referencing all pans and seam lengths greater than 10 ft. as Long Pan construction. This definition requires specific installation techniques as related to transverse seam and cleat location and design. See Detail C.

Copper expands approximately 1/8 in. per 10 ft. of pan length per 100°F temperature rise. A 30 ft. pan will therefore expand approximately 1/2 in. for a 150°F rise. This expansion must be accommodated. Such accommodation can be done either by fixing the pan at one end (accumulating the total expansion at the loose end) or by fixing the center of the pan (accumulating 1/2 of the total expansion at both free ends). In our example, we will assume a center location for cleats.

For a 30-ft. pan run, transverse seams should be staggered 12 in. from adjacent pans, which gives rise to 30-ft. and 28-ft. alternating pans. A common centerline for both pan lengths can now be determined. Fixed cleats are installed at the centerline and at 6 in. on center on either side of the centerline. Expansion cleats are installed at 12 in. o.c. for the remaining pan run. By fixing the center of the pans, this procedure has reduced the effective expansion length attributed to the pans to 15 ft. and 14 ft. for the two pan sizes, resulting in a maximum expansion of approximately 1/4 in. at the free end. See Detail C.

Most commercially available expansion cleats are designed to allow a maximum of 3/4 in. movement. Therefore, when set at midpoint, a total expansion of 3/8 in. can be accommodated in either direction.



Low-pitch transverse seam detail, from the Design Handbook.

Designing for Severe Wind Conditions

Copper roof systems have been used for over 300 years with great success. However, modern construction methods require credible testing procedures to verify system integrity and ability to withstand natural and man-made imposed loads and forces.

Because of many requests to provide data on the structural performance of copper roof systems, CDA contracted with Underwriters Laboratories (UL) to conduct a series of tests on various copper systems. The first of the tests subjected a copper standing seam roof to UL-580 Uplift Resistance Test Protocol.

The test panel consisted of UL's standard 10 ft.x10 ft. chamber with an insulated copper roof system on a metal deck and structural system. The system cross section is referenced in Detail D.

Of special interest are the stainless steel screws used to fasten the cleats to the deck and the polyethylene air barrier installed between the insulation and the structural steel deck.

At no time during the test did the copper system exhibit any unusual deformation, nor did any of the cleats work themselves loose from the structural deck. This system easily passed UL's test requirements and received the UL-90 designation.

It is important to note that other standing seam copper roof details can be designed to incorporate some of the details and techniques utilized for this test procedure. Upon request and submittal to UL, a review by UL staff of the proposed system can be undertaken and an opinion given as to whether the proposed system can meet the underlying designation.

Valley Flashing and Line Corrosion

The natural corrosion resistance of copper permits its use as an excellent long-lasting flashing material. Copper reacts with the atmosphere as it weathers and changes from a brown oxide surface and eventually to a gray-green copper patina.

This weathering reaction proceeds most rapidly when copper is exposed to dilute atmospheric moisture containing sulfur bearing rain or "acid rain." When these acids settle on copper surfaces, they react with the copper to yield basic copper sulfate (patina). This patina acts as a protective film and inhibits further weathering of the copper. Where the copper surface area is large, such as a copper roof, the total corrosive effect is slight because the reaction is spread over a large area, and the moisture loses its acidity upon reacting with the copper.

Acid moisture is normally not neutralized when it falls on non-copper roofing such as tile, slate, asphalt or wood shingles. This is particularly prevalent in valley flashing. In such a case, moisture may concentrate in small areas in contact with the copper, and damage to the copper can result. The risk of corrosion is most pronounced at the leading edge of shingles where the shingle edges rest directly on the copper flashing. Capillary action will retain highly acidic moisture in contact between the copper and the edge of the shingle. This can result in a linear pattern of pitting corrosion of the flashing, sometimes referred to as "line corrosion." Incorrectly installed flashing will promote line corrosion and substantially shorten the life of valley flashing.

To mitigate line corrosion conditions, CDA recommends the valley flashing Detail A from the *Design Handbook.*

Here, protection from line corrosion is achieved by raising the leading edge of the shingles by means of a cant strip. This effectively breaks the acid rain capillary action and promotes unhindered drainage of the water. The cant can be fabricated from wood blocking using copper straps soldered to the flashing as hold-downs or from an inverted V-shaped, 20 oz. copper strip soldered to the flashing. Raising the leading shingle edge approximately 5/8 in. is sufficient to break capillary action and prevent the acidic water from remaining at this interface, thus allowing free flowing drainage. Copper valley flashing has been used on many roofs and has far outlasted the underlying roofs without showing any signs of perforations or premature deterioration, if installed correctly. ■

Copper roofing resources

Copper In Architecture - Design Handbook is the Copper Development Association's compilation of designs, details, and specifications for installers and designers. It includes "more information than ever before assembled in one reference on the many, varied, and cost-effective ways copper and its alloys are being applied in architecture and building construction." 100 pgs. Call (212) 251-7200. $85.

For sheet metal and roofing contractors, the CDA offers **Installing Copper Roofing,** a six-part video program covering the installation of copper roofing systems and accessories and is aimed at the sheet metal or roofing contractor. Topics include concepts, flashing, standing seam, batten seam, and flat lock and soldered systems. 58 min. $35.

Revere calls the 7th edition of its **Copper and Common Sense,** first published in 1945, "the most widely referenced sheet copper design manual." Call (800) 448-1776. $18.

SMACNA's **Architectural Sheet Metal Manual,** 5th ed. (1993) contains many traditional sheet metal details used with copper. Contact www.smacna.org, or call (703) 803-2980. $176. to non-members.

For those involved in preservation or restoration work, SMACNA has republished its **Standard Practice in Sheet Metal Work** from 1929. The manual contains 1929 design data and illustrations, including pattern layouts. Architectural sections include elaborate cornices, skylights, domes, spires, gargoyles, metal buildings, and metal roofs. $189. to non-members.

For architects, CDA conducts **box lunch seminars** that introduce the architectural uses and applications of copper products through a one-hour slide presentation and a Q&A session. Design basics, common practices, and situations to avoid are discussed.

CDA's six-part videotape, **Copper in Architecture,** deals with various copper roofing systems, guttering, and flashing. The series is designed to give architects an overview of the basics — the fundamental forms, shapes, and details. $25.

The CDA also offers a range of **publications** on specific projects, applications, and problems. Visit www.copper.org/pub_list/architecture.html for a complete list with prices. ■

—compiled by MR staff

CDA's installer training program

The Copper Development Association offers an Installer Training Program which combines lectures by CDA staff members and coppersmiths directing shop instruction, with programs designed to fit a company's specific needs.

A two- or three-day program typically contains all the important training modules, and costs between $600 and $800 per day per coppersmith, plus expenses. (CDA absorbs its own costs.)

The program includes a lecture, which lasts 1-2 hours and covers the fundamentals of copper in architectural applications. This includes manufacturing techniques; physical properties; basic concepts (underlayments, thermal movement, galvanic activity, and corrosion); architectural systems; roofing, flashing, wall cladding, and interiors; projects and details (standing seam, flat seam, batten seam, domes, cupolas); finishes (lead-coated, pre-

patinated, clear coatings); environmental issues; and CDA resources.

Shop modules are instructed by a coppersmith and a CDA regional manager.

Shop Fabrication Techniques lasts around six hours, and demonstrates measurement, layout, and design of architectural sheet metal components used in the installation of all mock-up modules. The Equipment/Tools Demo lasts less than an hour, and is a review of the proper use of the most common equipment and tools.

The Soldering Techniques demonstration spans four hours. This module covers do's and don'ts, equipment selection, flux, pre-tinning and riveting, and flat- and steep-slope applications.

The Systems Menu allows companies to choose from a list of roof or wall cladding applications: standing seam, batten seam, flat-locked seam (soldered or unsoldered), barrel vaults, gutters, flashing systems, ridge details, and wall cladding systems. Systems components can be included with any of these systems, including eaves, rakes, ridges, valleys, panel fabrication, transverse seams, and expansion concepts.

No more than six students per instructor are permitted, with a maximum of 18 students, for the hands-on portion of the training. There may be as many observers as space allows.

Contact the CDA at (212) 251-7200 for more information. ■

Copper in Architecture CD-ROM

(The Copper in Architecture Design Handbook on CD-Rom)

This comprehensive resource contains technical discussions, sample projects, details and specifications on the application of architectural copper products. Details are AutoCad®-compatible for easy importing, or printable as PDF documents. Specifications are CSI and AIA MasterSpec®-formatted. Copper alloy color charts, along with supplier, manufacturer and contractor databases included. $20. Call Copper Development Association: 888-427-2411.

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