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Knowing Your Re-Roofing Options:
Making Decisions for Economy and Endurance

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Re-roofing projects usually begin with two questions: "How much is it going to cost?" and "How long before we have to do it again?" Owners and managers will reap the greatest benefit, however, by basing their re-roofing approach on three strategies:
1) knowing all the available options,
2) understanding the factors that affect roof longevity and costs, and
3) knowing the unique characteristics of the specific re-roofing situation.

Whether it's the cost or the longevity question, the desired result is the same: getting long-term value out of your new roof. That is best achieved by selecting a re-roofing system with the endurance and cost criteria that fit with the building's life-cycle costs, owner expectations, and specific roofing needs. These needs include watertightness of penetrations, insulation value for energy cost-savings, resistance to fire and wind, and accommodating the building's limitations (dead load, live load, height of flashings, etc.).

Cost-per-square-foot estimates and industry averages for longevity simply can't account for the vagaries of actual project conditions. Nor can the best of materials ensure quality installation. In the long run, there's nothing so expensive as a bad re-roofing job.

Finishing touches on a re-roofing project: Installation of ballast pavers and sheet copper hold-downs.

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Understanding the Options

Today's low-slope membrane roofing systems can be roughly broken into two categories: built-up roofing and single-ply roofing. Bituminous built-up roofing has been in use for more than 140 years, and appears on most commercial buildings constructed before 1965. Single-plies were introduced some 20 years ago, and include single-ply sheet membrane roofing and modified bitumen roofing.

Among the newest single-ply formulations are polymer-modified asphalt and rubberized asphalt products, which come in liquid-applied, self-adhering (peel-and-stick), mop-applied, and torched-on forms.

Each re-roofing approach offers benefits and drawbacks. A comprehensive survey of existing conditions and recommendations by a qualified architect or engineer will give the owner or facility manager the facts needed to make the best choice.

The Choices

Bituminous Built-Up Roofing

A bituminous built-up roof (BUR) is a continuous, semi-flexible membrane composed of plies of saturated felts, coated felts, fabrics, or mats. These plies are assembled in place with

Fully adhered EPDM roofing

1. Removal of existing roofing.

2. Installation of new roof drain.

3. Fastened insulation and adhered membrane.

4. Walkway pads and final touches.

alternate layers of bitumen that are usually applied in three or four layers. Because of their sensitivity to chemicals and ultraviolet (UV) light, BURs require a protective covering of mineral aggregate (gravel), a flood coat of bituminous material, or a granule-surfaced sheet.

BURs offer satisfactory performance, but require a higher degree of maintenance than other roofing types. Installation must also be closely supervised for optimum results. The primary problems are blistering of felts or cracking of the flood coat of bitumen ("alligatoring"). Blistering is usually attributed to BUR's very low permeability, while alligatoring is caused by loss of volatile oils from solar radiation.

There are two types of bitumen used in built-up roofing:

Asphalt bitumen is a naturally occurring substance which is also obtained through petroleum processing. Asphaltic BUR is still common, although its use is declining every year. It's labor-intensive and difficult to install properly, primarily due to the high heat and critical temperature ranges required.

Coal-tar bitumen is produced through the destructive distillation of coal. As a recognized carcinogen, coal-tar bitumen is also used less frequently today. Polymer-modified coal tar is now available as a high-performance alternative.

Single-Ply Roofing

As the name implies, single-ply roofing is installed in a single layer and in a single application. There are four types of single-ply roofing currently available:

■ The ***Elastomerics*** category is dominated by EPDM (Ethylene Propylene Diene Terpolymer), a synthetic rubber based in ethylene, propylene and a small amount of diene to provide vulcanization sites. Other elastomerics include neoprene, PIB, and epichlorohydrin. In general, elastomerics offer excellent resistance to heat, ozone, and weathering, and maintain vital flexibility at low temperatures (to as low as -60°C or -75°F), a prime consideration for roofing in northern climates. These systems can stretch and recover quickly from installation stress, thermal expansion, and building movement. Installation is relatively simple and does not require heat or flame. Elastomerics are best used for whole-roof replacement. These systems, however, are highly reliant on installer skills and abilities, and weather can affect adhesive drying times.

■ ***Thermoplastics*** include CPE (chlorinated polyethylene), PVC (polyvinyl chloride), CSPE, (a synthetic rubber of chlorosulfonated polyethylene that's manufactured under the tradename Hypalon™ by E.I. Du Pont de Nemours & Co.), as well as various "thermoplastic alloys" and "polymer alloys."

All thermoplastics use plasticizers for the required elasticity. The seams are heat-weldable, unlike EPDM systems, and, if properly installed, can reduce the risk of seam failure. Proper installation, however, is critical. During the heat-welding process, the membrane is uncured, which allows the thermoplastic material to melt and fuse together. Because of that, any change in surface temperature (including even that caused by a shadow cast over the roof) will result in non-uniform seam welding. Even fluctuations in the line voltage of the welding machine will cause adverse results.

In general, thermoplastic systems are more costly and more sensitive to installation error than EPDM and

rubberized asphalt systems. Their performance has historically been problematic, especially for PVC membranes and PVC-based polymer alloys. Repairs are difficult to perform, and plasticizer migration can occur for various reasons, leading to membrane brittleness and cracking.

■ *Modified Bitumen* is a popular re-roofing option, largely due to industry familiarity with the bituminous materials. Developed in the 1960s, modified bitumen roofing (MBR) is composed of asphalt, polymers to add flexibility and weatherability, and, in some cases, a UV-resistant surface material. In essence, MBR is a single-ply roof with the characteristics of a built-up roof. The sheet membrane, with its polymer-modified asphalt coating, is applied in a one- or two-layer application, and is either torch-applied or mopped down. MBRs are well-suited for repair and maintenance work on built-up roofs, especially in flashing areas.

■ *Rubberized Asphalt Membranes* can be adhered directly to a concrete substrate, making these a good choice for roof terraces, plaza decks over occupied space, or any concrete roof deck. It's essentially a simple peel-and-stick installation that is easy to effect, once parapets, penetrations, and other water-entry danger points are accommodated. The self-adhering quality prohibits leaks from traveling laterally along the deck, a major problem with loose-laid/ballasted roof systems and adhered systems with insulation between the deck and membrane. On the downside, rubberized asphalt membranes are UV-sensitive and require a total-coverage ballast.

Single-Ply vs. Built-Up Roofing

Just how well do single-plies stack up against conventional built-up roofing? The best measure is one that compares endurance, cost, and ease of installation.

Self-adhered rubberized asphalt sheet: Membrane installed and ready for insulation and pavers.

Endurance: Because of its long usage, built-up roofing has the advantages of industry familiarity and well-documented performance results. Conversely, single-ply roofing has only been in use in this country since the mid-70s, making life-span and endurance comparisons difficult. Hoffmann Architects, however, has been monitoring the performance of a single-ply roof it specified for installation 14 years ago; the roof is holding up quite well.

Cost: On a pure cost-per-square-foot basis, thermoplastics are the most expensive. Modified bitumens, rubberized asphalts, EPDMs, and BURs are comparable in cost **if** the old roof is removed first in all cases. If not, EPDM requires a separate membrane or "recover board" to keep it from direct contact with the old roof — increasing the cost.

It's vital to recognize, however, that initial expense is not the sole determinant in the ultimate cost of re-roofing. Ease of installation (which in turn reduces risk of failure), weatherability, strength, and overall endurance must be part of the final cost equation. Often, the most cost-effective solution for a re-roofing project isn't the cheapest in materials or installation, but is the one that pays off in longevity.

Installation: The installation process is perhaps the most important factor in the success of the new roof. Under ideal conditions with experienced installers, both single-plies and BURs will provide comparable watertightness and longevity. Unfortunately, installation conditions are rarely perfect. That fact alone puts BURs at the highest risk for failure. Single-plies are, across the board, easier to install and more forgiving of installer error.

Installation Comparisons

Built-up roofing installation is a heat-applied, temperature-critical process that requires close monitoring at every

When installing a new roof, don't forget the planters — they can leak as well.

stage. Each ply is laid and then coated with asphalt or coal tar. The roof deck must be completely free of moisture; even a slight drizzle during installation can cause small blistering on the roof surface. Misapplication of even one ply will affect the whole system, although some roofers may feel that the four-ply construction makes BUR a more "forgiving" material. Detail areas are particularly difficult, given the sheer physical difficulty of manhandling a three-foot-wide felt strip around intricate corners and protrusions.

Single-ply roofing installation falls into three main categories:

■ The ***totally adhered system*** is composed of insulation fastened to the deck, and the membrane adhered to the insulation with a full-coverage contact adhesive. This is a viable alternative to ballasted systems, as many structures aren't designed handle the added ballast weight. Installation is less vulnerable to specific temperature conditions, and can be done even in the winter, unlike built-up roofing. The exposed membrane makes it easy to locate any leaks that may occur over time, without having to remove all covering ballast first.

■ The ***self-adhering system*** adheres the membrane directly to a concrete deck, virtually precluding any chance of water traveling laterally along the deck. A prefabricated plastic drainage composite is placed over the membrane for positive drainage. A primer or surface conditioner is usually required, and concrete ballast pavers are needed for UV protection.

This is the easiest system to install, using a basic "peel-and-stick" technology. That ease of installation directly translates to reduced impact from installer error.

■ In the ***ballasted system,*** every component is loose-laid. The membrane is placed on top of the insulation, and then covered with ballast (usually pavers or stone) to hold the system in place. In a "protected membrane system," a water-resistant, extruded polystyrene insulation covers the loose-laid membrane, and is covered in turn by concrete ballast pavers. This adds another level of protection from temperature extremes and allows for free drainage of water around the polystyrene.

The primary problem with loose-laid systems is water access. If water does get beneath the membrane, it can freely flow across the roof deck and enter the building at penetrations through the concrete deck. Because water can enter a building at a location far from the original leak, tracing the leak source requires time-consuming removal of all ballast.

What's Our Vote?

Here are our top picks for re-roofing systems — and why:

Overall, *single-ply roofing* wins hands-down over built-up roofing. First, single-plies leave less room for installer error and on-site monitoring is more easily implemented. Single-plies are also less susceptible than BURs to temperature shifts and extremes during installation.

Fully adhered EPDM roofing detail shows an unusual drain condition.

On the performance side, *EPDMs* offer the best advantages of all the single-ply systems: good weatherability, flexibility at low temperatures, and overall endurance. Its inherent flexibility makes it easily adaptable to flashing conditions, roof configurations, and roof penetrations

On the installation side, our vote goes to the *totally adhered system.* Installation is straightforward and less susceptible to error. It allows for ongoing monitoring and maintenance of the new roof and provides the best watertightness.

As a runner-up, *rubberized asphalt systems,* such as W.R. Grace's Protected Roof Membrane Assembly system, combine the best aspects of adhered EPDM and protected membrane EPDM (insulation installed over the membrane, ballasted with pavers) — with the top benefit being leak prevention.

Last on our list is *modified bitumen roofing,* which offers great durability and watertightness, but depends heavily on installer expertise for optimum performance.

Ensuring Top Performance

Re-roofing is generally considered only after substantial leaks have developed and repairs have proved ineffective or cost-prohibitive. So any roof being considered for re-roofing is going to be wet, if not waterlogged — and should be fully removed for the best results. Removal will eliminate the danger of moisture trapped in the old insulation, and allow for complete inspection of the roof deck and repair of any rusted steel, spalled concrete, or other deterioration. Flashings and terminations should be checked at this point and properly installed at the appropriate height for the new roof.

Investigation of existing conditions is a vital part of any re-roofing project.

Preparation for outside corner detail on a modified bitumen roof.

Roof removal also ensures that the building's structural system will not be overly taxed, as no new weight will be added. A structural evaluation, however, is always necessary when a ballasted roof is being considered. Whichever system is selected, the architect should provide the owner with the following:

1. Complete specifications that meet, and, as required for the specific project, exceed the manufacturer's minimum requirements;
2. Detail drawings of every roof edge, termination, and penetration on the roof;
3. Consultation and review with the roofing system manufacturer to ensure that the new system will work under the existing conditions; and
4. An on-site representative to monitor and observe installation for compliance with the manufacturer's recommendations and the architect's contract documents.

Thorough substrate preparation is the leading factor in the success or failure of the re-roofing effort. Be sure to:

1) correct any spalling or deterioration of concrete decks,
2) repair loose areas of fill and any significant depressions to create a sound underlayment,
3) thoroughly address flashing details prior to installation to ensure optimum watertightness, and
4) make sure the surface is free of moisture, dirt, debris, and other contaminants which could affect installation.

A regular program of inspection and maintenance should be followed to help preserve the new roof. ■

Tips for Re-Roofing

One constant bedevilment of re-roofing projects is keeping the building watertight during renovation. The roofing contractor has to scramble like mad to tear off and replace as much of the old roof as possible in a single workday — a less-than-ideal working condition. The daily tie-ins between old and new sections that result from this usually end up as sources for leaks.

The solution? Temporary roofing. Several roofing manufacturers now offer a self-adhering, rubberized asphalt sheet that's installed as a single layer. This temporary roof protection lets the contractor remove large portions of the existing roof and still keep the building watertight. The improved working conditions help promote higher quality work as well, saving money over the long haul. These same membranes can be used for the main roofing — making them both temporary *and* permanent. In fact, that's one of the key benefits of rubberized asphalt membrane roofing, such as W. R. Grace's PRMA system. This is an expensive solution, however, and should be evaluated fully before proceeding. ■

Warranties Won't Keep Your Building Dry

The competition for your money is fierce in the world of roofing warranties, but your best bet is to ignore them altogether. It's a simple fact: no warranty is going to keep your building dry, no matter how much you pay for it.

The National Roofing Contractors' Association (NRCA) recently issued a Consumer Advisory Bulletin that states, "If the roof system is well-designed, well-constructed, and well-manufactured, the expense of purchasing a warranty may not be necessary. . . Long-term warranties are largely reactive, rather than proactive, solutions to roof problems. In general, they tend to undermine a prudent owner's concern for proper roofing specifications and application, as well as their subsequent responsibility for periodic roof maintenance."

It is useful, however, to look at what a manufacturer requires for a 15- or 20-year warranty — the most stringent in installation criteria. By looking at a manufacturer's "20-year system," you can quickly determine which of their materials are the most durable. There are other factors to consider as well: Is there a select list of approved qualified contractors for long-warranty projects? Are specific membrane materials, insulation materials, flashing details, extra stripping plies, or base sheets required? What specific application procedures are called for?

These longer-term warranty requirements can be very revealing, pointing out potential weaknesses in a particu-
(continued on page 8)

The Facility Manager's Bookshelf: **Roofing**

A. Basic References

1. *Roofing: Design Criteria, Options, Selection.* (by R.D. Herbert, III). R.S. Means Co., 235 pages. $59.95. ISBN 0-87629-104-3. Means catalog no. 67253.
2. *Facilities Maintenance and Repair Cost Data 1994.* R.S. Means Co., 500 pages. $199.95 (annual update $119.95). ISBN 0-87629-341-0. Means catalog no. 60304.
3. *How to Estimate with Metric Units.* R.S. Means Co., 200 pages. $46.95. ISBN 0-87629-317-8. Means catalog no. 67304.
4. *Means Illustrated Construction Dictionary.* R.S. Means Co., 700 pages, hardcover. $99.95. ISBN 0-87629-218-X. Means catalog no. 67292.

To order: Call R.S. Means Co. at 1-800-334-3509 (American Express, VISA, MasterCard) or write to 100 Construction Plaza, P.O. Box 800, Kingston, MA 02364-9988.

B. General Reading

1. Bonin, H. W. and C. J. Thorp, "Design of a Neutron Gauge for the Detection and Measurement of Water Ingression in Flat Roofs." *Nuclear Technology,* Volume 95, September 1991. pps. 337 - 348.
2. Chaney, Elizabeth M., "Controlling Delay Claims." *Architectural Record,* Volume 181, March 1993. pps. 22 - 25.
3. Gorman, T.M. and D.N. Reese. "Roof-system Replacement On Sports Arena." *Journal of Performance of Constructed Facilities,* Volume 5, May 1991. pps. 124 - 133.
4. Petersen, W. "Selecting Tapered Roofing Insulation." *Plant Engineering,* Volume 45, March 21, 1991. pps. 117 - 118.
5. Sutton, Judy. "Dry Ideas: Administrators Adopt a More Pro-active, Hands-on Approach to Roofing Retrofit." *American School & University,* Volume 65, June 1993. pps. 26 - 29.

If your company does not have a source for ordering copies of these articles, call Michigan Information Transfer Source (313-763-5060) at the University of Michigan, Ann Arbor, MI, to inquire about their document delivery service.

C. Construction Specifications Institute

1. Laaly, Heshmat O. "Flashings and Counterflashings." *The Construction Specifier.* November 1993, p. 56
2. Petersen, Wayne. "Solving Problems With Protected Membrane Roofing." *The Construction Specifier.* November 1985, p. 78.
3. Schroeder, Edward K. "Regarding Roof Edges." *The Construction Specifier.* November 1993, p. 40.
4. Tente, Paul. "Roofing's Unconsidered Factors." *The Construction Specifier.* August 1981, p. 10.

To order: Specifier Reprints, 601 Madison Street, Alexandria, VA 22314-1791, (703) 684-0300. (Cost: $4.00 each, $10.00 minimum).

D. Past issues of Hoffmann Architects' JOURNAL

1. "Avoiding Added Wear and Tear to Roofing." Volume 10, No. 2, 1992.
2. "Re-roofing Options: A Guide To Selecting the Right System." Volume 8, No. 3, 1990.

To order: Call Emily D. Dowden, Hoffmann Architects at (203) 239-6660.

Compiled by Alan P. Eddy, Technical Information Specialist ■

REPRESENTATIVE PROJECTS

Roof Rehabilitation

Hoffmann Architects specializes in the rehabilitation of the exteriors of existing buildings. A major portion of the firm's practice involves roof rehabilitation, including repair and replacement of membranes, insulation, decks, flashing, and parapets.

Its professional architects and engineers conduct surveys to investigate problem areas, determine causes of deterioration, analyze structural integrity, and evaluate roof life expectancy.

The firm prepares detailed plans and specifications for competitive bidding of re-roofing projects. Contract administrators and on-site project representatives track the progress and quality of construction.

Hoffmann Architects has provided roof rehabilitation services for numerous buildings.

Among these are the following projects:

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Bank of Boston Connecticut Headquarters
Waterbury, Connecticut
(Bank of Boston Connecticut)

Kingsborough Community College
Brooklyn, New York
(Dormitory Authority of the State of New York)

555 Fifth Avenue
New York, New York
(Atco Properties and Management, Inc.)

Bristol-Myers Squibb Company
Wallingford, Connecticut
(Bristol-Myers Squibb Company)

Taft Apartment Complex
New Haven, Connecticut
(MONY Real Estate Investment Management)

Vassar College Avery Hall
Poughkeepsie, New York
(Cesar Pelli & Associates Inc.)

Hoffmann-La Roche Headquarters
Nutley, New Jersey
(Hoffmann-La Roche, Inc.)

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New York, New York
(Rockefeller Center Management Corporation)

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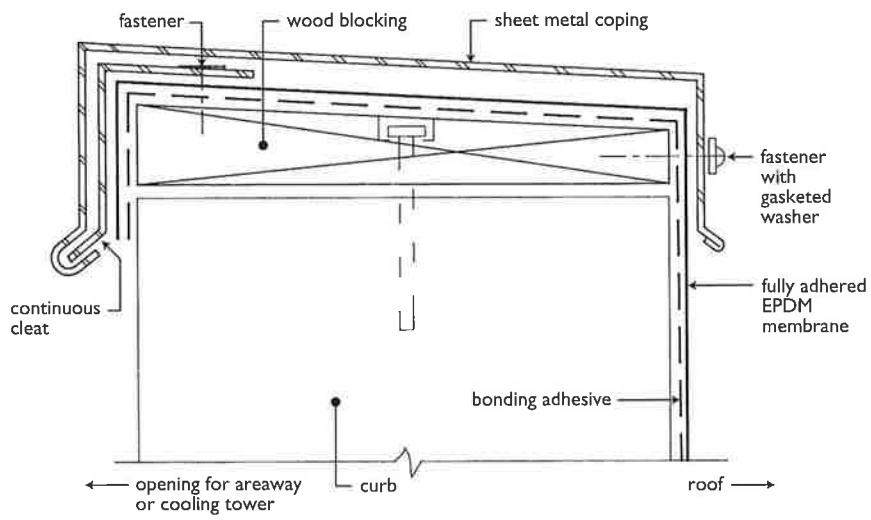

Figure 1: Sheet metal curb coping detail for an EPDM roof. For a watertight roof, the roof membrane must be continuous, as shown here.

lar roofing technology or manufacturer's product. The longer-term warranty will require extra or redundant provisions for these areas, covering both recommended details and application procedures.

Even if you're not pursuing the longer-term warranty, you'd do well to select a contractor from the manufacturer's approved list. These contractors obviously received substantial training and certification from the manufacturer in order to qualify for the select list.

Warranty or not, nothing can replace a thorough initial investigation of existing conditions to determine the original cause of roof failure. Fix the problems first before re-roofing. After all, it's of little use to put on a new roof if water can still get in through a leaking parapet. ■

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