

# Roofing Solutions

## Why Roof Maintenance Pays

# Making a case for Roof Maintenance

BY ROBERT W. LYONS, FRCI · LYONS / WALDRON CONSULTING GROUP, LLC

In this period of tough economic pressure and uncertainty, it is imperative for building owners and anyone in the facilities maintenance and management profession to spend their monies wisely and manage their facility assets properly. The ultimate goal should be to achieve maximum service life at the least possible cost. For this reason, life-cycle costing has never been more appropriate.

Frankly, we live in a world looking for short-term, quick fix solutions. We often compromise the end-goal by taking the road of least resistance. When it comes to our commercial roofing portfolios, we frequently have the misconception that if our roofs are not leaking, we don't need to bother with them. This out-of-sight, out-of-mind perspective is one of the root causes for premature roofing failures. We need to adopt a proactive roof maintenance protocol to ensure the maximum service life from our roofing system, and to reduce the collateral damage caused by leaking roofs at our facilities.

### Starting fresh

If a building owner starts out with a problematic roofing system, the situation typically goes downhill from there, creating a maintenance nightmare. So let's assume we are starting out with a reasonably good roofing installation as part of a new construction process or a complete tear-off and reroofing.

Our goal is to immediately—from year #1—take on a preventive maintenance program to ensure the maximum service life of this good roof.

Additionally, with the new long-term warranties that most building owners desire (10 years +), you are contractually responsible to perform annual (or semi-annual) roof inspections and the associated repairs in order to maintain the terms of your extended warranty. These reports should be filed with records of the corrective work that has been performed. There are numerous roof management database programs available to help streamline this process (see “New tools help owners track roofing assets,” later in this Guide).

Progressive roofing manufacturers like GAF are also offering building owners incentives for scheduled maintenance. The company's Well Roof Advantage program will extend a Diamond Pledge guarantee at no cost for a term equal to 25% of the original guarantee length when a GAF roof is inspected and main-

tained by a Master Select Roofing Contractor.

As far as cost, roofing industry experts say that a building owner should budget a minimum of \$0.05 per square foot per year for preventive maintenance (beginning in year #1) for their commercial roof; and that at periodic intervals during the life of the roof, they would be advised to spend as much as \$0.25 per square foot for a more extensive remedial restoration.

Economic models support that the payback for these types of expenditures can be significant in helping to reduce the frequency of reroofing and the large capital expenditures they create. In the process, it is feasible to extend the life of a 10 year+ roofing system to a 20-year roofing system, or longer.

There have been many innovative roofing systems developed for the commercial roofing market in the past decade, and there have been even more new products developed for the ongoing maintenance and restoration of these systems.

GAF's TOPCOAT restoration system, for example, offers a 10-year warranty with 100% coverage against material defects. With 85%+ reflectivity, this can mean up to \$70,000 in energy

## Managing your company's roof

1. Use life-cycle costing to assure maximum roof service life.
2. Adapt a pro-active roof maintenance protocol.
3. Perform semi-annual roof inspections and repairs.
4. Budget a minimum of \$ .05 per square foot per year for preventative maintenance (beginning in year #1).
5. Budget \$0.25 per square foot for a more extensive remedial restoration.
6. Track all collateral building damage and incidental costs associated with leaking roofs.
7. Show management how past collateral damage costs exceed the cost of implementing a roof maintenance and management program.

## What can cause immediate problems?

### ▶ Extreme Weather...

Lightning, high winds, hail, drenching rains that overflow the flashing heights

### ▶ Equipment Additions...

Improperly added equipment or other items improperly added on the roof (items added by tenants are a very common source of roofing problems)

### ▶ Trade Damage...

Punctures, holes, etc. caused by trades other than your roofing contractor

### ▶ Unintended Abuse...

Vandalism or accidental damage...even a small hole can let in a large amount of water into the roofing system

saving over a 15-year period on a 50,000 square foot roof. Moreover, the system is proven, with more than 15 million square feet installed since 1979.

The coatings industry has taken a leadership role in the development of many of these new restoration systems, and the prognosis looks favorable on their performance in the field. Built-up roofing systems, single-ply roofing systems, modified bitumen roofing systems, and metal roofing systems all now have coating and restoration systems that have been developed for the purpose of extending their service lives.

One of the short-sighted ruts that building owners have gotten themselves into is waiting too long to initiate any kind of a proactive roof maintenance and management program. This only cheats them out of realizing the full potential service life of any of their roofing systems within their overall portfolio.

To help get buy-in and support from your senior management team, we would recommend that you begin tracking all collateral building damage and incidental costs associated with having dysfunctional, leaky roofs. Often, the collateral damage costs greatly exceed the cost of implementing a roof maintenance and management program.

To help provide a list of costs and expenses to track, your company CFO can provide you with:

- Costs of damage to building interiors (furnishings & fixtures)
- Costs of damage to merchandise and inventory
- Costs of damage to equipment (computers, electrical, HVAC, etc.)
- Costs from lost use of space
- Costs and exposure to issues of air quality and work environment
- Costs of legal claims ("slip & fall" accidents)

- Costs of water damage clean-up
- Costs of energy loss through wet and damp roof insulation in both the heating and cooling seasons
- Costs of business interruption
- Costs associated with higher insurance premiums due to more frequent claims arising from water damage
- Costs of premature roof replacement

We are firmly convinced that if more facility managers would track and report these collateral damage expenses, they would have less resistance to getting the resources they need to establish a model roof maintenance and management program.

There is a false economic perspective that is pervasive in this area. It is not a question of will you spend the money; it is more of question of when, where and how you will spend the money on your roofs.

The good news is that it costs less to be proactive than reactive. And it does help to reduce the stress. And who among us could not benefit from a little budget savings and stress reduction? **RSI**

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# Roofing Solutions

## Why Roof Maintenance Pays

Is maintenance a good investment?

# Try the math

**R**oofing systems are assets, and have a finite life expectancy. Life spans have ranged widely from as little as five years to documented cases of 50 years or more. However, most

membrane roofing systems will be replaced or can expect to receive significant renovation in less than 20 years.

Few people would purchase a new car and not change the oil to protect their major investment. Unfortunately, once an investment is made in a roof system, the roof is out of sight and is unlikely to get much thought until there is a problem. By then, damage may be extensive.

Figure 1

### Assumptions

- Roof Size:** 100,000 square feet
- Study Period:** 20 years
- Cost of Initial Roof System:** \$300,000
- Hurdle Rate:** \$10%
- Roof Replacement Cost:** \$500,000
- Leak Repairs:** \$750 each occurrence
- Interior Damage from Leaks:** \$500 each occurrence
- Wasted Energy:** \$1.08/ft./year
- Inspection Program:** \$1,000/year
- Visual Surveys:** \$1,000/Year
- Moisture Surveys:** \$5,000 each

It takes good financial controls and a corporate commitment to ensure that the roof is maintained. The good news is that the payback can be spectacular over the long-term. (Please see Figure 2).

### Crunching the numbers

The goal of this study is to express, in financial terms, the value of Roof Maintenance Management. Still another goal is to enable the roof to perform its primary mission: to protect the interior of the building.

Another goal is to conserve energy by keeping the insulation dry. Since wet insulation loses effectiveness, a dollar value can be assigned to this wasted fuel cost.

The long-term presence of wet roofing materials can have other consequences. In its most dramatic manifestation of neglect, roof decks have failed, endangering roofing workers and/or occupants beneath. Disintegrated components such as rotted nailers and corroded insulation fasteners, have contributed to catastrophic wind blow-off.

Before we begin our financial analysis, let's address some of the frequently asked questions pertaining to Roof Maintenance Management.

Figure 2

Roof Maintenance Alternatives	Reactive (1)	Moderate (2)	Aggressive (3)
Capital	\$800,000	\$625,000	\$300,000
Leak Repairs	\$21,000	\$9,000	\$5,000
Total Consequential Costs	\$4,984	\$2,566	
Total Asset Management Program Costs		\$41,000	\$58,000
Preventative Repair Costs		\$2,250	\$4,500
Total Repair Consequential & Management Costs	\$25,984	\$54,816	\$67,500
Total Investment Value (Net present value)	\$503,921	\$394,756	\$284,928
Uniform Capitol Recovery	\$40,436	\$31,676	\$22,863

### How much should we be spending on our Roof Maintenance Program?

Before we answer this question, let's see what we'll need:

**1. Visual surveys**—roofs should be visually examined twice a year. Damage surveys should be conducted after periods of violent weather or after a roof has been subjected to construction traffic.

**2. Moisture surveys**—insulated roofs should also be surveyed by nondestructive means on a periodic basis. This might be on a 2-5 year interval, as well as just prior to making major decisions on the fate of the roof system.

#### Step #1

#### Roof maintenance program costs:

\$0.10-\$0.15 per square foot, per year.

Including the overhead to manage a moisture survey program, 10 to 15 cents per square foot, per year, is not unreasonable.

An owner who plans to perform sizeable repairs on older roofs might expend 45-50 cents per square foot for labor and materials.



**For comparison with roof management, here are some estimates for roof replacement:**

Tear off and install a new roof.....	\$2.50-\$3.50/ft <sup>2</sup>
New construction.....	\$2.00-\$3.00/ft <sup>2</sup>
Recover.....	\$2.25-\$3.25/ft <sup>2</sup>
Wood deck replacement.....	\$1.50/ft <sup>2</sup>
Steel deck replacement.....	\$3.50/ft <sup>2</sup>

**Start-up costs for an effective Roof Management program would include:**

- Acquisition of software
- Acquisition of hardware
- Operator and inspector training
- Acquisition of the initial detailed database
- Establishment of an emergency plan

In the event of a catastrophe, an Emergency Plan would include a 24-hour directory of key personnel, establishing an initial inventory of repair materials, having a cache of tools, tarps, buckets, wet vacs and other emergency gear, and having a 24/7 contact with a local roofing contractor. Costs should include training of personnel.

**Is Maintenance Management worth the cost and effort?**

That is the crux of this article. We will follow a "textbook" example 1 for correct protocol.

**Step #2**

**Study Parameters:**

- Study Period = 20 years
- Roof Area = 100,000/ft<sup>2</sup>
- Cost of Initial Roofing System = \$300,000
- Hurdle Rate = 10%

**A Life-Cycle Study**

**Approach #1: A Passive Program**

- No formal maintenance program
- Repair roof only when it leaks
- Take no precautions to protect roof warranty
- Replace roof at end of 10 years

**Assumption—Capital Costs**

- Installation cost.....\$3.00/ft<sup>2</sup> = \$300,000
- Replace cost.....\$5.00/ft<sup>2</sup> = \$500,000\*

\*Assume total removal due to wet insulation, as well as some corroded decking and rotted nailers.

**Assumption—Maintenance Costs**

- Inspection program = none
- Leak repair @ \$750 each by roofing contractor

We will assume no leaks or repairs for two years (contractor warranty usually lasts two years). From year 3-7, we will assume one leak/repair per year;

By year 8, the roof condition is worsening, and the roofing contractor is called back twice—three times in year 9—and four times in year 10. By now, we are sufficiently frustrated that we decide to tear the entire roof system off and start the cycle again.

**Assumption—Wasted Energy**

Compare the 'R' value of wet insulation material to dry and calculate the "excess" fuel used during both the heating and cooling cycle.

**Assumptions—Fixing Leaks**

Since we have no maintenance program, we must bring in a roofing contractor at \$750.00 for each callback. Repairs begin in year 3 and accelerate in years 8-10. The cycle repeats for the second roof.

**Assumptions—Interior Damage**

While we allowed for some deck, insulation and nailer replacement in the reroof during year 11, there is interior damage as well. We have estimated the cost at \$500.00, incurred in years 5, 8, 11 (after installing new roof), 15 and 18.

**Step #3**

**Life Cycle Cost Analysis:**

The total investment (net present value) for the Passive Maintenance Program is \$503,921.

**Approach #2: Active Maintenance Program**

- Moderate Maintenance Program
- One visual survey per year
- Moisture survey only at year 15, prior to recovering
- Damaged areas repaired, rather than just "patched"

**Assumption—Capital Costs**

- Initial cost .....\$3.00/ft<sup>2</sup> = \$300,000 (year 0)
- Replace cost\*...\$3.25/ft<sup>2</sup> = \$325,000 (year 16)

\*Recover: Old roof left in place, wet areas removed

**Assumption—Maintenance Costs**

- Inspection program overhead.....\$0.01/ft<sup>2</sup> = \$1,000/year
- Visual survey (once/year).....\$0.01/ft<sup>2</sup> = \$1,000/year
- Moisture Survey (year 15 to determine extent of wet insulation).....\$5,000 each
- Leak repairs by trained crew.....\$250 each
- One repair each year from 3 to 15, 17 to 20
- Interior damage.....\$500 each (Repairs in years 7 and 16 only)

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## Assumption—Wasted Energy.....\$1.08/ft<sup>2</sup>/year

One new leak (about 5' x 5' in area) in years 3, 5, 7, 9, 11, 13, 15, 18 and 20

No moisture survey is conducted, except in year 15 (to prepare budget for re-cover in year 16). Even though leakage is minimized, some wet areas occur and are undiscovered.

## Approach #3: Pro-Active Program (Recommended)

- Visual surveys twice per year, plus after severe storms at .01¢/ft<sup>2</sup> each
- Moisture surveys on a 3-year cycle at .05¢/ft<sup>2</sup> each
- Maintain data base, manage roofs and warranty service at .02¢/ft<sup>2</sup>/year

## Assumption—Capital Costs

- Initial cost.....\$3.00/ft<sup>2</sup>
- Replacement in year 21 (not part of study period). By properly repairing the roof promptly and detecting wet materials, we are able to recover in year 21 with virtually no deck, nailer or insulation replacement.

### Step #4

Roof maintenance saves \$218,993 in Year 21, which can be put toward the cost of a new roof.

## Assumption—Maintenance Costs

- Visual surveys.....\$0.02/ft<sup>2</sup> = \$2,000/year
- Repairs at \$250 each  
(In every year, starting in year 3 when contractor's warranty ends)
- Moisture survey.....\$0.05¢/ft<sup>2</sup> = \$5,000 each  
(In years 3, 6, 9, 12, 15, 18)

## ANNUAL COSTS DEPRECIATION

For corporations that are not tax exempt, depreciation may be an important factor. As part of the tax reform bill of 1993, depreciation of structures completed (or roofs capitalized) after May of 1993 must use straight-line depreciation over 39 years (previously 31.5).

## SUMMARY OF THIS LIFE CYCLE EXAMPLE

Assuming a new roof is installed in year 21 at a cost of \$325,000, the \$218,993 saved (Total Investment Value) compared to a passive maintenance program will pay 67% of the cost of the new roof.

Example #3 with a conscientious Roof Maintenance Management Program reduces the annual roofing costs of this 1,000 square



After Year 21, roof restoration is another option if the roof has been well maintained.

### Step #5

An aggressive roof maintenance program reduces annual roofing costs by \$17,573.

roof from \$40,436 to \$22,863—a savings of \$17,573 (17.6¢/ft<sup>2</sup>) each and every year over the 20-year study period.

This example provides a credible method of finding the best value for a building system. We are confident that your analysis will also show that roof management is always a good investment. **RSI**

## References

ASTM E917: ASTM, 100 Barr Harbor Drive, W. Conshohocken, PA 19428-2959, [www.astm.org](http://www.astm.org).



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## Why Roof Maintenance Pays

# Proof that roof maintenance pays big dividends

Or, how not to lose \$0.15 per square foot per year on your roofs

BY CHUCK MARVIN, RRC

### Case history: the Polygram Facility

In July of 1996, the Polygram facility was approaching 20 years of age. Excluding air handling equipment, there had never been more than a couple of minor roof leaks at any given time. The vast majority of time, the facility was leak free during rain storms due to an aggressive roof maintenance program.

How much benefit was realized from the aggressive maintenance program for this building?

The answer is a great deal (see charts).

### Why roof maintenance worked

The Polygram story begins with its original roof survey, including an infrared scan, that located and defined six wet areas of insulation. Each subsequent year, up to three new wet areas were discovered until the last year, when the number jumped to six.

Each year all wet insulation was replaced and new roofing installed. The cost of this restoration process is a valid factor in selecting a maintenance approach. Wet areas average out to be about 30 sq. ft. The largest one identified was in 1988 at only 120 sq. ft. This means they were repaired while still small.

Based on the facility being approximately 220,000 sq. ft. and the program being provided over a seven-year period, the cost is only \$0.03 per sq. ft. per year. Remember also that this

### Polygram Facility

**Roof Size:** 220,000 square feet

**Cost of aggressive roof maintenance program:**  
\$0.03 per year

**Roof and related costs without a maintenance program:**  
\$0.15 per year

**Annual cost to owner of not having a roof maintenance program:**  
\$54,700 per year

program was started after the roofs exceeded 10 years of age. The earlier years are typically much less costly and would pull this average lower still.

This \$0.03 per sq. ft. number is exactly the estimated cost Dennis Firman suggested based on his experience with more than 600 million sq. ft. of roofing with the U.S. Air Force. A review of five other clients conducting this type of aggressive maintenance program for at least five years also proved to be around this \$0.03 number. It is accurate to say the cost of an aggressive maintenance program will fall between \$0.03 and \$0.04 per year, per sq. ft.

### The costly alternative

Firman suggests the choice not to have maintenance program can cost an owner as much as \$0.15 per sq. ft., per year. Based on this estimate, the owner would be losing \$33,000 per year. If only a fraction of this amount is correct, the cost savings more than offset the most aggressive maintenance programs.

At this point we decided to see what this facility would look like if only patching was done to stop leaks with minimum maintenance. Very conservative estimates were used to paint a best-case scenario for the owner.

Included in the study were actual infrared photos of one wet area taken eight months apart. In that time, the area of wet insulation increased 20% or more. However, to be ultra-conservative, we charted linear dimensions of the wet areas to expand at a rate of only 5% per year. Of course, this comparison is unrealistic in evaluating the true cost to the client. If the wet insulation remains, the following are sure to happen:

A. Freeze thaw cycles will cause

### Cost without a roof maintenance program\*

**Year 1.....\$135,000**

Tear-off of roof section #2; more than 20% of insulation wet in six locations, ranging from 30 to 120 square feet in size.

**Year 2.....\$0**

Nothing is done. However, wet insulation increases in roof sections #1 and #3

**Year 3.....\$135,000**

Complete tear-off required for roof section #1.

**Year 4.....\$180,000**

Complete tear-off of roof section #3.

**Year 5.....\$20,000**

Major replacement and repairs for misc. areas

**FIVE YEAR TOTAL: \$470,000**

\*Based on a conservative estimate of expansion of existing wet areas (30-120 square feet); assumes (unrealistic) cost advantage of no money spent prior to Year 1.

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# Roofing Solutions

**“The decision not to employ an aggressive roof maintenance program is costing owners between \$0.10 and \$0.15 per sq. ft. per year.”**

**—Dennis Firman, P.E., U.S. Air Force**

splits and accelerate the leaks and saturation of insulation. This takes place because the moisture is left in the insulation.

**B.** Wet insulation does not insulate and will cost substantially more through wasted energy dollars. Our client heats and cools the facility. Ask yourself: What effect would several hundred or thousand square feet of uninsulated roof area have on your monthly bill?

**C.** Structural concerns arise due to water weight gain and corrosion of structural components. This adds remedial cost and becomes a potential safety issue.

## Owner's bottom line

Now, let's compare a best case scenario for the low maintenance approach versus a worst case for aggressive maintenance: low maintenance: \$470,00 versus aggressive maintenance at \$196,500. The savings equal \$273,500. There is also tens of thousands in energy savings, return on capital and more.

With a maintenance program spanning 13 years and square footage of about 220,000 square feet, the cost savings per square foot, per year is close to \$0.10. This is based on making the aggressive program look as cost ineffective as possible. Firman's conclusion of \$0.15 is probably more realistic.

Assumptions play a huge role in this type of costing and are always subject to challenge. To effectively manage your roofing assets, you must be proactive. To what degree and at what cost are the questions. Try your own numbers with your own assumptions. You will likely find the aggressive approach will save you substantial time and money.

It is conservatively accurate for us to tell building owners that their business decision not to employ an aggressive maintenance program is costing them between \$0.10 and \$0.15 per sq. ft. per year. Now, multiply this times the number of square feet you own or manage and show this bottom line as an annual loss. It's a powerful argument to start a formal roof maintenance program today.

Update: A few years ago, my North Carolina client initiated recovery for all of his roofs. They were all past 20 years of age and never experienced more than a few minor leaks in any given year thanks to an aggressive roof maintenance program. At the time of recovery, no wet insulation was found and the metal deck remained structurally sound. **RSI**

## Cost of aggressive roof maintenance program

Year 1.....	\$14K
Year 2.....	\$4.5K
Year 3.....	\$5K
Year 4.....	\$4K
Year 5.....	\$5K
Year 6.....	\$6K
Year 7.....	\$8K
<b>Total.....</b>	<b>\$46.5K</b>

## Why facility manager Gerry Martin chose to maintain his roofs

If a building owner spends \$500,000 on one roof replacement, while several other restorable roofs fail, he is making a grave mistake. If repairs can buy a few years (or the leaks do not present a safety hazard, structural concern, or otherwise can be controlled) then he should spend the money to prevent failures first.

The problem is that if the roof does not leak into the building and an aggressive maintenance plan is absent, the owner will not know a roof is in trouble until it is too late. Roofing

contractors and consultants should be convincing their clients to make aggressive maintenance a high priority.

Dennis Firman, PE, the U.S. Air Force's maintenance chief, said way back in 1988 that an owner's choice not to have a maintenance program could cost him \$0.15 per square foot, per year. Why is it, then, that so few owners have aggressive maintenance programs for their roofing assets?

More recent articles in RSI Magazine suggest that a minimum of \$0.07 per square foot is lost per year based on a for-

mula included in the ASTM E-917 standard (www.astm.org).

To come up with an accurate number, I asked a few of my long established clients for help. Upon review of the written responses, one client stood out: a large manufacturer in North Carolina that produces compact discs and has critical production areas inside. Gerry Martin was in charge of correcting and maintaining the roofs that were about 12 years old back in 1988. Some leaks were occurring which needed repair; however, his focus was always on maximizing their long-term service life.

As a result, Martin set up an aggressive maintenance program. Hard choices were made in response to several recommendations from different sources. Martin's choice to employ an aggressive program has easily saved his company several hundred thousand dollars, and the savings are well documented.

#### Contrasting approaches

The first approach to roof maintenance is to do nothing. This entails calling for repairs only when the roof leaks. A moderate maintenance plan would require visually inspecting the roof once a

year or so and perhaps scanning it near the end to determine if a recover is possible. An aggressive approach would be to have a formal inspection twice a year combined with an annual moisture survey. An in-depth, computerized management program should be included for large, more complicated facilities.

Depending on the roof's construction, different equipment would be used for moisture surveys to maximize effectiveness. For this client's example, infrared was chosen.

Based upon the documented results obtained, there are few exceptions where an aggressive program with annual moisture surveys would not be my recommendation today. The following represents the original situation, reasoning for selecting the aggressive maintenance plan, and the results.

The general construction of the Polygram facility roof consisted of a metal deck, 3" perlite (two 1.5" layers mopped together) and four-ply asphalt built-up organic felts with flood coat and rock surfacing.

#### Status in late 1988

A few leaks existed over clean room type environments. A general survey was conducted to recommend short and long-term needs. The inspection included a moisture survey with infrared scan and membrane tensile-strength evaluations.

Approximately six wet areas were defined. The largest area was roughly 120 sq. ft. while the smallest was closer to 2' by 4'.

One existing roof leak was identified as originating from a smaller wet area located with the scan. Negative air pressure in air handling units was creating leaks blamed on the roofs. Once properly identified, this was handled separately.

Problems existed, however. Walkways trapped water underneath, rotting the membrane, and drain valleys ponded water for several days after rains. The roof also had substantial traffic to service the formidable amount of equipment on the roof. These conditions, along with voids or other installation shortcomings, allowed for an occasional leak to develop. But for its size, this facility was in relatively good shape.

#### Rationale for program selection

Based on the above findings, replacing the wet areas of insulation and roofing was specified. Additionally, repairs to the walktreads, pitch pockets, flashing and other items were included.

To reduce the massive amounts of ponding water in the valleys, the installation of additional drains was recommended. This is where things became more complicated. The near clean room environment inside the building would mean the loss of critical production time. Also, if dust and debris reached the production equipment, a work stoppage would be required for a thorough inspection. The amount of money lost could pay for the replacement of an entire roof section.

Drains were the right choice from a roofing standpoint. Unfortunately, the clean room conditions in the plant eliminated this as an option.

Not being able to include drains to ensure a sound roofing system helped in deciding to incorporate the aggressive maintenance program as a compromise. Two visual inspections combined with an infrared moisture survey annually would identify any potentially critical problems before they fully developed.

As it turned out, this aggressive roof maintenance plan saved the building owner \$470,000 over a five-year period. **RSI**

Author Charles Marvin founded Roof Solutions Inc., an independent consulting firm, in 1994. Marvin has designed roof systems for Manhattan public parks, 47 New York skyscrapers and developed plans for heavy industrial plants, hospitals, schools and shopping malls. He is the recipient of the Richard M. Horowitz Award for excellence in technical writing (1998) and assisted in two reroofing projects on the perimeter of Ground Zero after the collapse of the World Trade Center in 2001. He is a member of the Roof Consultants Institute and National Roofing Contractors Association.

**“Martin's choice to employ an aggressive maintenance program has easily saved his company several hundred thousand dollars.”**