# A Case Study of a Best Value Manufacturer

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This is a case study of a construction product manufacturer's effort to become a profitable manufacturer of roofing systems while providing a best value product to the client (best performance at the lowest cost.) The manufacturer was attempting to become successful with product performance in an industry where low performance of competing products brought a perceived high risk of nonperformance from clients. The manufacturer's efforts included documentation of performance of the installed product, creating a risk management process, testing the risk management process and creating a supply chain structure which minimized the risk of both the manufacturer and the client. The key component of a best value manufacturer is the identification of the true buyer of their materials is the owner of the facility which buys their product and not the contractors. This paper documents the transformation, the risk management approach, and the problems encountered in the transformation. This paper shows how the manufacturer documented its product performance, created a performance based contractor system, and utilized a risk management process (the Performance Information Risk Management System or PIRMS).

**Keywords:** Coatings, Roofing, Waterproofing, Best Value, High Performance, Neogard

## Introduction

In the 1990's Neogard (a manufacturer of high performance industrial coatings) was faced with a problem in the sprayed polyurethane foam (SPF) roofing industry. They were embedded into an industry where manufacturers/contractors sold products to clients based on warranties that did not protect or minimize the risk of the client. SPF roof system performance was very unpredictable. Clients were buying roofing based on the long term stated duration of the warranty, which had no proven correlation with proven/documented performance periods. The warranties were embedded with disclaimers or exclusions that made many of the warranties difficult to enforce. The practice of some manufacturers cast a pall over the entire industry.

Deductive logic and common sense identify that a warranty protects the manufacturer and not the client:

1. The warranty is a contractual document between the manufacturer of the product and the client.
2. The warranty is written by a lawyer who represents the manufacturer.
3. The warranty has no proven correlation with actual performance periods.
4. The warranty has to be enforced.
5. The client has to prove that the roofing system they purchased does not meet the stated purpose, and that the manufacturer is responsible for the problem.
6. The client has to prove that they did not cause the problem.

7. The client must then get the roofing manufacturer to acknowledge the problem, acknowledge that they will fix the problem, and actually fix the problem.

In the sprayed urethane foam industry, which is one of the industries Neogard provides their products, an owner may have difficulty in getting a manufacturer to react to problems covered by the warranty and to fix the source of the problems. Manufacturers in the SPF industry do not keep performance records on their product or their applicators. The SPF roof system is one of the most complicated to install because it is installed on site, using a two component SPF which is highly reactive to not being mixed in proper proportions, at the right temperature (which requires very high and accurate heating), with proper equipment and installation, and in an environment must be free of moisture. There are cases where the SPF or coating manufacturers have not responded to client concerns, have had their products installed in a suboptimal manner by contractors who were either not capable of installing the SPF roof systems properly or who were not paying proper attention to the constraints of the project environment, and who did not provide adequate supervision on the projects.

The authors have personal knowledge of a very large SPF roof manufacturer warranty representative who gave the following responses to a client over a period of five years on a SPF roof installation:

1. We have never had that problem before.
2. It is due to contractor error.
3. It was fixed (when it was not fixed.)
4. We have the contractor scheduled to come out and take a look at it (and no one showed.)
5. The contractor has done the repairs (and the repairs are not done properly and led to more problems.)
6. We have paid the contractor to make the repairs (and no one made the repairs.)
7. The manufacturer's warranty representative came out and took a look at the roof (and no one visited the site.)
8. The manufacturer determined it is contractor error, and the manufacturer is not liable (even if the contractor is a qualified applicator.)

SPF and coating manufacturers use distribution systems to sell material to contractors and minimize their liability. By doing this, they do not have liability for nonperformance caused by improper installation. Owners, who do not understand the impact of product distribution systems, do not know the difference between a systems warranty that covers nonperformance due to materials and installation and a materials only warranty. When there is a materials only warranty, it is very difficult to prove that the problem was not caused by improper application.

A properly installed coated SPF roof system installed in a retrofit environment is a very green, sustainable, cost effective, and extremely value oriented roof system. This is only if it is installed by a highly qualified contractor, using very high performance coating and SPF materials. However, if all these factors are not present, a roof owner can find himself with a roofing fiasco, which explains why, over the last 20 years despite some very high performance, the percentage of SPF roof systems has not increased over 5% of the roofing market. The most important step a potential roof owner can make when purchasing a high performance SPF roof

system is to identify if the manufacturers and contractors have documented proven performance and a quality control/risk management system that will protect the roof owner.

Neogard found itself in a very uncomfortable position as a manufacturer of high performance installed products, in an industry which was filled with false promises and low priced and low performing competitive systems. Neogard is a manufacturer of an aromatic urethane coating for sprayed in place polyurethane foam (SPF) roof systems. There were facing the following challenges:

1. The false perception that all urethane coatings including their high performance product called "Permathane" had a problem with reversion (the transformation from a solid back to its initial two component liquid state).
2. Marketing and sales people of other manufacturers who were selling aliphatic coatings. Aliphatic coatings were a high solids, higher bonding urethane material that exhibited a higher initial gloss than Neogard's aromatic "Permathane" coating. However, the aliphatic coatings did not have the proven documented performance of the Permathane coating. The aliphatic coatings started to fail (reversion and cracking due to brittleness) while the aromatic Permathane coating became the highest performing coating.
3. Other roofing material manufacturers outside of the SPF industry were identifying the SPF systems as inexpensive and temporary roofing system which could not handle foot traffic (which was true of many of the other acrylic and silicone coated SPF systems, but not the properly installed Permathane coated SPF roof system.)
4. An entry of an "inexpensive" aggregate covered SPF roof system that was being sold for half the price of a urethane coated SPF roof system but oftentimes due to its extremely low cost, lacked the quality of installation of the higher performing SPF systems.
5. Contractors were installing systems material which were not always the highest performing, but rather the quickest and easiest to install. This included systems which used a quick two coat system instead of a three or four coat urethane elastomeric coating system.
6. Manufacturers were selling the SPF system materials through distribution where contractor performance was not a requirement to purchase the material, leading to many failures of SPF systems.

## Problem

The problem is one faced by many manufacturers of products in the construction industry. How does a manufacturer of high performance products differentiate their product from the manufacturers who are producing commodity products which may have inconsistent performance, high risk, and lower pricing? How would a high performance manufacturer protect itself against low performing contractors who did not act in the best interest of the manufacturer or the client? How would the manufacturer protect itself against other manufacturers' lower cost products that may be used in place of their more costly high performing systems? How does a manufacturer of high performing systems sustain itself in a low priced marketplace?

In 1996 Thom Tisthammer, one of the foremost experts in the installation of sprayed polyurethane foam (SPF) roofing, and an applicator of Neogard's high performance

"Permathane" coated sprayed polyurethane foam (SPF) roof system, introduced Mike Steele, President of Neogard, to Dr. Dean Kashiwagi, Director of the Performance Based Studies Research Group (PBSRG) at Arizona State University (ASU.) He encouraged Neogard to adopt some of the performance based concepts being proposed by PBSRG.

The PBSRG was a well known research group in the United States and developed performance based procurement systems, including the Performance Information Procurement System (PIPS) and the Performance Information Risk Management System (PIRMS). These tools maximize the value of construction systems and protect the client against the risk of non-performance. PBSRG proposed that the problem of nonperforming construction was a systems problem caused by the client's price based procurement system. PBSRG was encouraging owners to use past performance measurements on both the manufacturer and contractors performance to minimize the risk of nonperformance in the delivery of roofing systems.

At this time, Neogard was contemplating leaving the roofing marketplace due to the litigation and risk of nonperformance of their installed roof systems. The risk was very high, costs were increasing and the profit margins were decreasing. Neogard requested PBSRG investigate whether it was possible to change the competitive climate by doing the following:

1. Identify a method to differentiate Neogard's high performance products and roof systems from other manufacturers based on product performance.
2. Create a structure whereby to identify high performance contractors who could install Neogard products, minimizing the risk of nonperformance caused by improper installation.
3. Create a process that would motivate contractors to minimize risk through preplanning, adequate pricing, and using best practices and qualified personnel.
4. Institute a transparent, information based environment that would motivate contractors to fix the problems caused by application error instead of forcing the manufacturer to pay for the problem,
5. Identify a method to identify high performance clients who could understand the value of Neogard's products.
6. Identify a strategic plan to maximize the sales of Neogard's products.

## Hypothesis

The hypothesis of this research was that a manufacturer of high performance products could be successful in the construction industry in a price based environment. Successful would be determined by the ability to differentiate itself by performance, to minimize risk of nonperformance, to increase sales and profit, and to have satisfied clients of their installed systems.

## Methodology

This research project will use the deductive logic approach. It will use common sense concepts that are well recognized in general business and apply the concepts to confirming the hypothesis. The following steps will be used:

1. Identify if Neogard had a high performance product and that their product could be differentiated based on a dominant environmental requirement.
2. Use the Construction Industry Structure (CIS) model to identify which environments would result in their company being the most sustainable and what practices should be implemented.
3. Create and test a risk minimizing contractor program which would dominantly identify the performance of the manufacturer's product.
4. Create a risk management system that would minimize the risk of nonperformance of their installed systems.
5. Align the high performance supply with clients who would understand the value of their installed systems.
6. Identify how Neogard could implement the risk minimization contractor program, risk management program, and alignment with high performance clients.

## Identification of a High Performance Product

PBSRG asked Neogard to identify why they perceived their urethane coated (Permathane) coating as the highest performing coating system for SPF. Neogard listed the following attributes:

1. Joint and several warranty.
2. Performance in heavy hail areas.
3. Longevity in the performance of its coating systems.

PBSRG conducted two research projects in 1996 and 1999:

1. Initial hail test of Neogard's coatings (urethane, silicone, and acrylic coatings) in accordance with FM-SH Test # 4470. The research tests were expanded to include in-field tests of installed systems.
2. Follow-on oversized hail testing using the FM-SH test specification for larger sized hail and also for cold weather testing with temperatures around 32 degrees Fahrenheit.

The Factory Mutual Severe Hail Test (FM-SH) #4470 has the following major components:

1. Testing the samples dropping a 1-3/4 inch steel ball from 17-3/4 feet on the coated sample which is prepared according to the specifications of the installed system.
2. Aging the sample in a weatherometer, and retesting the samples.
3. The FM-SH test did not include field testing of aged systems. The correlation between the weatherometer aged systems and actual aged systems in the field has not been confirmed.

The 1996 tests results included (Kashiwagi, 1996):

1. The only test sample that passed the FM-SH test requirements at coating thicknesses that were currently being specified was the moisture cured urethane Permathane coating.
2. Field tests of installed silicone, acrylic, and urethane coatings resulted in identifying the moisture cured Permathane coating as the only coating that passed the FM-SH test requirement of not breaching the coating when hit by a 1-3/4 inch steel ball dropped from 17-3/4 ft elevation.
3. These results conflicted with the FM test results which passed all three coating systems. Follow discussion with FM to retest the samples based on the ASU testing was unsuccessful.

The 1999 "Oversized Hail" test results" included (Kashiwagi, 1999):

1. Permathane coating installed at 45 mils average, and 35 mils minimum thicknesses could withstand a much larger size hailstone (up to four inches in diameter) without fracturing/breaking through the coating.
2. The coating could potentially perform at freezing temperatures.

Follow up hail testing using the FM-SH requirements in field conditions conducted in 2008 and 2009 (Tables 1 and 2) on the moisture cured urethane Permathane coating has yielded the following results:

1. Requirements successfully passed on a 22 year old roof installed at the Casa View Elementary School in 1987. The roof coating had an average thickness of 49 mils, and a maximum thickness of 50 mils.
2. Requirement successfully passed on four roofs in Torrington and Cheyenne, Wyoming with an average age of 16 years (maximum 19, minimum 13 years) with an average coating thickness of 32 mils and an average minimum of 16 mils. Each roof tested had an expected life of 10 years.
3. Requirement was also partially met in the Fall of 2008 while running the FM-SH tests in deck temperatures of 49 degrees Fahrenheit. The system may not be able to pass if the coating thickness is less than 45 mil average / 35 mil minimum. Tests that failed at 53 degrees F had an average coating thickness of 28 mils (standard deviation of 9 mils) and a minimum thickness of 12 mils (standard deviation of 5 mils.) Tests that succeeded had an average coating thickness of 35 mils (standard deviation of 11 mils) and minimum thickness of 21 mils (standard deviation of 10 mils.)

Table 1

***Overall Resistance to Hail***

| No | Criteria | Unit | Fall | Summer | Failed | Passed |
|---|---|---|---|---|---|---|
| 1 | Average Surface Temperature (F) | Degrees F | 53 | 152 | 49 | 103 |
| 2 | Average Coating Thickness | Mils | 32 | 35 | 28 | 35 |
| 3 | Average Coating Thickness – Std. Deviation | Mils | 11 | 9 | 9 | 11 |
| 4 | Minimum Coating Thickness | Mils | 18 | 21 | 12 | 21 |
| 5 | Minimum Coating Thickness – Std. Deviation | Mils | 10 | 8 | 5 | 10 |
| 6 | Maximum Coating Thickness | Mils | 40 | 46 | 35 | 43 |
| 7 | Maximum Coating Thickness – Std. Deviation | Mils | 9 | 8 | 8 | 8 |
| 8 | Number of Drops | # | 58 | 40 | 17 | 81 |

Note. Fall tests were conducted in November 2008. Summer tests were conducted in August 2009.

Table 2

***Roof System Performance***

| No | Job | Size | Year Installed | Age When Tested | Customer Satisfaction | Ever Leaked? | Currently Leak? |
|---|---|---|---|---|---|---|---|
| 1 | EWC: Kitchen | 17,000 | 1993 | 16 | 10.0 | No | No |
| 2 | EWC: Tebbets Backwings | 21,000 | 1990 | 19 | 10.0 | No | No |
| 3 | EWC: Fine Arts Classroom | 13,000 | 1994 | 15 | 10.0 | Yes | No |
| 4 | State of WY: Surplus Bldg | 17,500 | 1996 | 13 | 10.0 | No | No |
| 5 | Dallas ISD: Casa View ES | 61,100 | 1987 | 22 | 9.0 | Yes | No |

Note. Roofs 1, 2, and 3 are in Torrington, WY, roof 4 is in Cheyenne, WY, and roof 5 is in Dallas, TX.

The test results on the majority of the roof systems were done on 40 psi SPF with 35 mils average thickness of Permathane (minimum thickness of 21 mils.) The high performance Alpha system that is warranted against FM-SH size hail damage is specified at 45 mils average thickness (35 mils minimum) with a 15 year service period. These hail test results differentiate the Neogard Permathane coated SPF roof system in the following ways:

1. It is the only coated SPF roof system that has proven documented hail resistance of over 15 years.
2. It is the only coated SPF roof system that has documented performance in hail areas without recoating for 20 years.
3. It shows documented performance with minimal degradation for 20 years.

The hail resistance and performance of the aged Permathane systems shows both durability and resistance against loading such as foot traffic for an extended period of time that is unusual for SPF roof systems. The system is lightweight, monolithic, has the highest insulating capability, and its renewable structure give it physical and economical advantages over conventional built up roofing and modified bitumen systems in retrofit situations when the existing roofing system does not have to be removed. The biggest constraint to installing a high performance SPF roof system is having a high performance contractor who can install high performing materials properly.

## Construction Industry Structure (CIS) Business Approach

The CIS approach (Figure 1) is a simplistic and yet sophisticated strategy. The approach has different objectives for each of the three stable environments, which are the priced based environment, the best value environment, and the negotiated bid environment. The best value environment is where high performance contractors compete based on value (performance and price.) This is an environment where the contractors and manufacturers document the performance for the product in terms of the following factors:

1. Customer satisfaction.
2. Percent of roofs leaking.
3. Percent of roofs that do not leak.
4. Percent of roofs that never leaked for any reason.
5. Percent of roofs with more than one percent deterioration.
6. Maximum, average, maximum age of the roof system.
7. Age-sum of the roofs that never leaked (adding up the number of years of all roofs that have never leaked.)
8. Average number of traffic on the roofs.
9. Average area of the roofs.
10. Percent of roofs with more than .25/12 slope.
11. Number of penetrations per area of the roof (roof failure is increased by penetrations due to flashing details.

The best value environment is where there is an alignment of the manufacturer's high performance product, the high performance skills of the contractor, the use of performance information in the selection of the contractor which ensures that the client is a best value client, and the use of logical, common sense risk management practices. In the best value environment, the best value client transfers the risk, control, and accountability to the best value vendor. The risk of nonperformance and high costs is almost non-existent if the following is accomplished:

1. Contractors are measured in terms of performance.
2. Client transfers the risk of nonperformance to the contractor, and forces contractors to identify, manage, and minimize risk that they usually do not control.
3. Contractor and manufacturer identify to the client the technical scope of the project as a part of their preplanning.
4. Contractors use a risk management plan to manage and minimize the risk they do not control.
5. Contractors use a weekly risk report to document deviations to their installation plan.
6. Contractors minimize the risk of nonperformance during and after the installation for the duration of the warranty period.

The only way to economically minimize the risk of the warranty period is to have minimal risk. Minimal risk is the result when the vendor is an expert in the installation (they know what they are doing) and using high performance products. Warranties have less meaning in this environment, due to the minimized risk of high performance contractors installing a high

performance product. Warranties only minimize the risk of lower performing manufacturers and contractors.

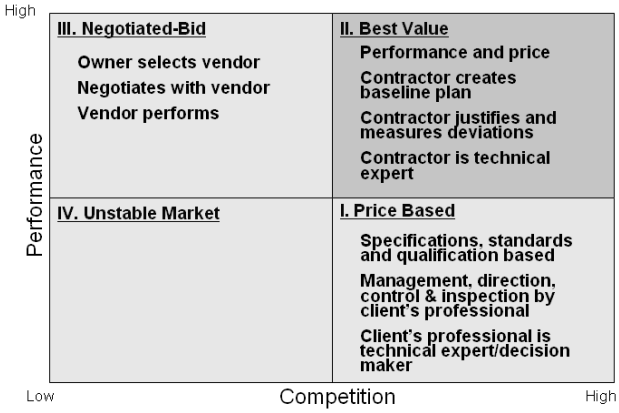


*Figure 1*: Construction Industry Structure

In the price based arena, clients perceive that all installed products have the same performance and the best value is the lowest possible price. Characteristics of the priced based environment include:

1. The client and the client's representative are the expert. They direct the vendor on what to do, how to do it, manage and control the vendor's installation, and only buy the lowest priced alternative.
2. The manufacturer and contractor have very low risk. They use the warranty to further minimize their risk.
3. Manufacturers use the system of distribution in the price based environment, further separating themselves from any liability of the installation of their products. Warranties are usually material only, and if labor and materials are also covered, the manufacturer will force the client to prove the source of the nonperformance.
4. Manufacturers and contractors sell in large quantities at lower profit margins.
5. There is no monitoring and risk and performance of products, systems, or contractors.

There are two other subtle assumptions in the price based arena. First, the client assumes someone can perfectly identify what is required and what will happen and perfectly communicate that to a second entity or individual. Secondly, the second entity or individual perfectly understands the perception/expectation of the first individual/entity. The third assumption is that this concept can be transferred to and understood by not only one entity but three or four individuals/entities. And because they are all equal, the low price is the best value. However, when the low price entity is selected, many times it is perceived by the buyer/client that the low price vendor does not understand the requirement how to install the system to meet the expected performance.

The owner's representative then assumes falsely that they can manage, direct, and control the vendor during the installation and after the installation during the entire service period identified

by the contract/warranty. This has proven to be ineffective, inefficient, and leads to transaction laden outcomes. Many clients do not understand that the manufacturers of the products have a difficult time controlling the performance of their own contractors. The low price environment structure is responsible for the resulting low level of performance and high risk of the roofing market. This is especially true for the SPF roof system.

In the negotiated bid arena, the quality should be of the same level as the best value environment; however, in many cases the following is not present due to the lack of competition:

1. Performance measurements.
2. Documented risk management system.
3. Tracking of performance after installation.
4. Effectiveness and efficiency of the best value environment.

Using the CIS business approach, the construction industry and clients of the construction industry operate in all three environments. To maximize profit and sustainability, the CIS approach dictates that Neogard do the following:

1. Release all control to the clients in deciding what environment they are requesting the product installation. They must therefore offer their products/installed system in all three environments.
2. To maximize their profit, they must have a foundation of performance that is ensured by a quality control/risk management system, performance measurements, and a performance based contractor program in the best value environment.
3. They must market their products in the price based and negotiated environments using the potential performance of high performance installations.

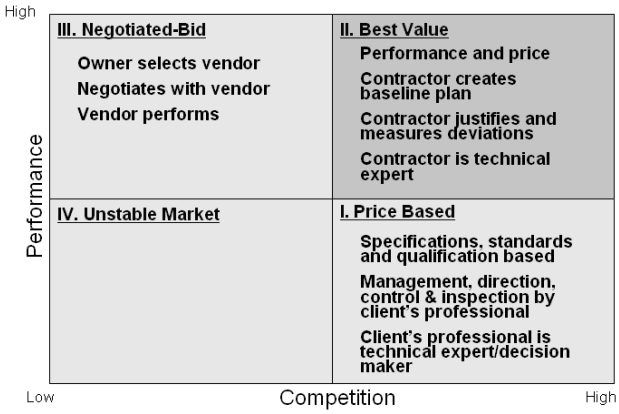


*Figure 2*: CIS Solution

## High Performance Roofing Program

Over the last ten years, a performance based roofing program was developed for Neogard called the Alpha program. It is the only performance based contractor program run by a manufacturer

in the roofing industry. The requirements of the Alpha roofing program was initially set by the high performance contractors participating in the program and were modified over time to increase the effectiveness and efficiency of the program. The requirements of the program include:

1. Have a "good financial standing" with the manufacturer (Neogard.)
2. Five year experience and listing of 50 roofs or documented installation of 10 (Permathane) roofs (totaling 150,000SF.)
3. Roof inspections once every two years of a maximum of 50 roofs, and a minimum of 15 roofs.
4. Annual submission of newly installed SPF roofs over 5,000 SF to Arizona State University
5. 98% of roofs being tracked cannot currently leak.
6. 98% of surveyed roofs must have satisfied customers.
7. The contractors must attend the annual educational presentation given by Arizona State University on the risk management systems.
8. Tracking of performance of all other vendors of material in the Neogard system.

The program is performance based because entry into and exit from the program is based on performance measurements. All contractors must document their performance with periodical inspections and the third party verification. Random calls by a third party are made to verify the performance of a contractor. Contractors are eliminated from the program if they do not maintain the 98% customer satisfaction of their documented roofs (with a minimum 70% client response rate required.) Contractors could also be eliminated from the program if they did not meet the financial requirements of Neogard, or if the manufacturer decided that the contractor was not acting in the best interest of the Alpha program or Neogard.

The best value clients are procuring the product based on proven, documented performance and the assurance that the contractor/manufacturer has a risk management system in place to minimize risk. The manufacturer runs the risk management system to minimize its risk of liability and litigation that is caused by improper application. The high performance Alpha system has the following advantages:

1. Performance measurements force accountability of contractors to install the product/roof system correctly.
2. Risk management systems force contractors to manage and minimize the risk that they do not control, risk that they usually are not responsible for.
3. Risk management forces contractors to identify their assumptions, constraints and potential risks, and forces them to preplan to manage and minimize the risks, and to identify any deviations to their preplanned scope.
4. The performance measurements assist the contractor and their personnel to continuously improve.
5. An environment of preplanning, risk management, and performance measurements increases the technical and professional skill of the contractors and their personnel and will attract the best of vendors and their personnel.

Since the Alpha Program's inception, 11 contractors have dropped out. The major reasons for discontinuing involvement are summarized below.

Table 3

***Contractor Reasons for Discontinuing Involvement***

| No | Criteria | Rating |
|---|---|---|
| 1 | Did not keep up with performance data list and inspections | 64% |
| 2 | Terminated from program | 19% |
| 4 | Switched business market | 10% |
| 5 | Competed with Neogard | 10% |

Table 4 shows the performance ratings of the contractors involved in the program. Table 5 shows the progression of the performance since the inception of the program. Tables 6 and 7 highlight a couple contractors who have been in the program multiple years, and show their performance over the last three years. Manufacturers and contractors can use the performance information for continuous improvement, relative comparison of performance and value, and to prove to clients that their roofing system performance is not based simply on a manufacturer's warranty. The collection of performance information is the only one of its kind in the SPF roofing industry, the roofing industry, or the waterproofing industry. For more information, browse to www.pbsrg.com.

Table 4

***Current Alpha Contractor Performance Lines (Contractors A – D)***

| No | Job | Unit | A | B | C | D |
|---|---|---|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | 9.1 | 10.0 | 9.7 | 10.0 |
| 2 | Oldest job surveyed | Years | 23 | 3 | 19 | 23 |
| 3 | Average age of jobs surveyed | Years | 10 | 1 | 12 | 8 |
| 4 | Age sum of all projects that never leaked | Years | 150 | 14 | 119 | 77 |
| 5 | Age sum of all projects that do not leak | Years | 358 | 19 | 144 | 145 |
| 6 | Percent of customers that would purchase again | % | 100% | 100% | 100% | 100% |
| 7 | Percent of jobs that do not leak | % | 92% | 100% | 100% | 100% |
| 8 | Percent of jobs completed on time | % | 100% | 100% | 100% | 100% |
| 9 | Percent of satisfied customers | % | 97% | 100% | 100% | 100% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 100% | 100% | 100% | 100% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 96% | 100% | 96% | 100% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 89% | 93% | 89% | 100% |
| 13 | Average job area (of jobs surveyed and inspected) | SQ | 497 | 569 | 122 | 234 |
| 14 | Total job area (of job surveyed and inspected) | SQ | 24,334 | 8,529 | 3,300 | 5,845 |
| 15 | Total number of returned surveys / Num. of jobs surveyed | # | 39 / 54 | 14 / 15 | 12 / 27 | 18 / 26 |
| 16 | Total number of jobs inspected | # | 54 | 15 | 27 | 26 |
| 17 | Total num. of different customers surveyed & inspected | # | 32 | 5 | 15 | 11 |
| 18 | Total number of Alpha Inspection Surveys | # | 4 | 1 | 5 | 3 |
| 19 | Certification Status | Status | US | C | C | C |

Note: Under "Certification Status", US stands for "Under Survey" and C stands for "Current"

Table 4, cont'd

***Current Alpha Contractor Performance Lines (Contractors E – I)***

| No | Job | Unit | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | 9.8 | 9.8 | 9.8 | 9.8 | 9.8 |
| 2 | Oldest job surveyed | Years | 27 | 5 | 13 | 33 | 17 |
| 3 | Average age of jobs surveyed | Years | 18 | 4 | 5 | 19 | 10 |
| 4 | Age sum of all projects that never leaked | Years | 785 | 173 | 70 | 388 | 194 |
| 5 | Age sum of all projects that do not leak | Years | 863 | 201 | 116 | 800 | 287 |
| 6 | Percent of customers that would purchase again | % | 100% | 100% | 100% | 100% | 100% |
| 7 | Percent of jobs that do not leak | % | 100% | 100% | 100% | 100% | 100% |
| 8 | Percent of jobs completed on time | % | 100% | 100% | 100% | 100% | 100% |
| 9 | Percent of satisfied customers | % | 100% | 100% | 100% | 100% | 100% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 100% | 100% | 56% | 100% | 100% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 98% | 98% | 63% | 92% | 98% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 88% | 93% | 60% | 94% | 100% |
| 13 | Average job area (of jobs surveyed and inspected) | SQ | 195 | 419 | 196 | 778 | 248 |
| 14 | Total job area (of job surveyed and inspected) | SQ | 9,940 | 22,207 | 8,213 | 38,899 | 14,907 |
| 15 | Total number of returned surveys / Num. of jobs surveyed | # | 49 / 51 | 53 / 53 | 22 / 42 | 44 / 51 | 30 / 60 |
| 16 | Total number of jobs inspected | # | 51 | 53 | 16 | 51 | 60 |
| 17 | Total num. of different customers surveyed & inspected | # | 6 | 2 | 27 | 19 | 48 |
| 18 | Total number of Alpha Inspection Surveys | # | 9 | 4 | 2 | 5 | 5 |
| 19 | Certification Status | Status | C | C | C | C | US |

Note: Under "Certification Status", US stands for "Under Survey" and C stands for "Current"

Table 4, cont'd

***Current Alpha Contractor Performance Lines (Contractors J – N)***

| No | Job | Unit | J | K | L | M | N |
|---|---|---|---|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | 9.8 | 9.7 | 10.0 | 8.7 | 9.7 |
| 2 | Oldest job surveyed | Years | 23 | 11 | 7 | 26 | 6 |
| 3 | Average age of jobs surveyed | Years | 12 | 7 | 3 | 9 | 3 |
| 4 | Age sum of all projects that never leaked | Years | 303 | 206 | 77 | 213 | 99 |
| 5 | Age sum of all projects that do not leak | Years | 425 | 274 | 77 | 438 | 116 |
| 6 | Percent of customers that would purchase again | % | 100% | 100% | 100% | 100% | 100% |
| 7 | Percent of jobs that do not leak | % | 100% | 100% | 100% | 100% | 100% |
| 8 | Percent of jobs completed on time | % | 100% | 100% | 100% | 100% | 100% |
| 9 | Percent of satisfied customers | % | 100% | 100% | 100% | 100% | 100% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 100% | 100% | 100% | 98% | 100% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 100% | 100% | 100% | 90% | 91% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 100% | 100% | 92% | 24% | 85% |
| 13 | Average job area (of jobs surveyed and inspected) | SQ | 579 | 178 | 238 | 327 | 59 |
| 14 | Total job area (of job surveyed and inspected) | SQ | 28,379 | 9,639 | 5,703 | 16,679 | 3,188 |
| 15 | Total number of returned surveys / Num. of jobs surveyed | # | 35 / 50 | 39 / 54 | 24 / 24 | 47 / 51 | 41 / 55 |
| 16 | Total number of jobs inspected | # | 17 | 54 | 24 | 51 | 55 |
| 17 | Total num. of different customers surveyed & inspected | # | 25 | 9 | 1 | 5 | 48 |
| 18 | Total number of Alpha Inspection Surveys | # | 5 | 1 | 1 | 6 | 1 |
| 19 | Certification Status | Status | C | C | C | US | C |

Note: Under "Certification Status", US stands for "Under Survey" and C stands for "Current"

Table 4, cont'd

***Current Alpha Contractor Performance Lines (Summary of All Alpha Contractors)***

| No | Job | Unit | Overall |
|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | 9.8 |
| 2 | Oldest job surveyed | Years | 33 |
| 3 | Average age of jobs surveyed | Years | 9 |
| 4 | Age sum of all projects that never leaked | Years | 2,654 |
| 5 | Age sum of all projects that do not leak | Years | 3,825 |
| 6 | Percent of customers that would purchase again | % | 100% |
| 7 | Percent of jobs that do not leak | % | 99% |
| 8 | Percent of jobs completed on time | % | 100% |
| 9 | Percent of satisfied customers | % | 100% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 99% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 96% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 89% |
| 13 | Average job area (of jobs surveyed and inspected) | SQ | 332 |
| 14 | Total job area (of job surveyed and inspected) | SQ | 200,905 |
| 15 | Total number of returned surveys / Num. of jobs surveyed | # | 420 / 615 |
| 16 | Total number of jobs inspected | # | 556 |
| 17 | Total num. of different customers surveyed & inspected | # | 255 |
| 18 | Total number of Alpha Inspection Surveys | # | N/A |
| 19 | Certification Status | Status | N/A |

Note: Under "Certification Status", US stands for "Under Survey" and C stands for "Current"

Table 5

***Yearly Inspection Performance Lines***

| No | Job | Unit | 1991 | 1993 | 1995 | 1996 |
|---|---|---|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | N/A | N/A | N/A | N/A |
| 2 | Oldest job surveyed | Years | 12 | 14 | 15 | 20 |
| 3 | Average age of jobs surveyed | Years | 6 | 7 | 6 | 6 |
| 4 | Age sum of all projects that never leaked | Years | 205 | 285 | 585 | 378 |
| 5 | Age sum of all projects that do not leak | Years | 235 | 303 | 665 | 573 |
| 6 | Percent of customers that would purchase again | % | 100% | 100% | 100% | 100% |
| 7 | Percent of jobs that do not leak | % | 95% | 98% | 100% | 100% |
| 8 | Percent of jobs completed on time | % | 100% | 100% | 100% | 100% |
| 9 | Percent of satisfied customers | % | 98% | 98% | 100% | 100% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 86% | 86% | 90% | 58% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 89% | 96% | 96% | 100% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 48% | 49% | 58% | 38% |
| 13 | Total job area (of job surveyed and inspected) | SQ | 3,873 | 4,115 | 23,627 | 29,592 |
| 14 | Total number of returned surveys / Num. of jobs surveyed | # | 41 / 66 | 54 / 71 | 107 / 142 | 94 / 102 |
| 15 | Total number of jobs inspected | # | 66 | 71 | 142 | 102 |
| 16 | Total num. of different customers surveyed & inspected | # | 39 | 40 | 90 | 18 |
| 17 | Total number of different Alpha contractors | # | 1 | 1 | 1 | 2 |

Table 5, cont'd

***Yearly Inspection Performance Lines***

| No | Job | Unit | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | 9.9 | 8.6 | 9.2 | 9.0 |
| 2 | Oldest job surveyed | Years | 18 | 26 | 19 | 24 |
| 3 | Average age of jobs surveyed | Years | 5 | 6 | 8 | 8 |
| 4 | Age sum of all projects that never leaked | Years | 545 | 1,527 | 1,482 | 774 |
| 5 | Age sum of all projects that do not leak | Years | 643 | 2,415 | 1,592 | 1,540 |
| 6 | Percent of customers that would purchase again | % | 100% | 100% | 100% | 100% |
| 7 | Percent of jobs that do not leak | % | 100% | 99% | 100% | 99% |
| 8 | Percent of jobs completed on time | % | 100% | 94% | 98% | 95% |
| 9 | Percent of satisfied customers | % | 100% | 99% | 100% | 96% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 70% | 60% | 85% | 82% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 97% | 85% | 97% | 89% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 62% | 57% | 62% | 56% |
| 13 | Total job area (of job surveyed and inspected) | SQ | 36,723 | 133,695 | 66,440 | 136,975 |
| 14 | Total number of returned surveys / Num. of jobs surveyed | # | 130 / 173 | 388 / 521 | 230 / 270 | 193 / 411 |
| 15 | Total number of jobs inspected | # | 173 | 521 | 270 | 411 |
| 16 | Total num. of different customers surveyed & inspected | # | 82 | 312 | 99 | 221 |
| 17 | Total number of different Alpha contractors | # | 3 | 8 | 5 | 8 |

Table 5, cont'd

***Yearly Inspection Performance Lines***

| No | Job | Unit | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | 9.0 | 9.5 | 9.8 | 9.5 |
| 2 | Oldest job surveyed | Years | 27 | 16 | 29 | 28 |
| 3 | Average age of jobs surveyed | Years | 10 | 7 | 10 | 9 |
| 4 | Age sum of all projects that never leaked | Years | 1,124 | 525 | 1,475 | 581 |
| 5 | Age sum of all projects that do not leak | Years | 1,575 | 695 | 2,574 | 875 |
| 6 | Percent of customers that would purchase again | % | 100% | 99% | 100% | 100% |
| 7 | Percent of jobs that do not leak | % | 100% | 99% | 100% | 100% |
| 8 | Percent of jobs completed on time | % | 100% | 97% | 100% | 99% |
| 9 | Percent of satisfied customers | % | 99% | 96% | 100% | 100% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 66% | 69% | 96% | 82% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 97% | 97% | 97% | 97% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 47% | 47% | 69% | 73% |
| 13 | Total job area (of job surveyed and inspected) | SQ | 56,042 | 52,246 | 107,529 | 71,977 |
| 14 | Total number of returned surveys / Num. of jobs surveyed | # | 167 / 204 | 107 / 147 | 255 / 356 | 100 / 142 |
| 15 | Total number of jobs inspected | # | 204 | 147 | 356 | 142 |
| 16 | Total num. of different customers surveyed & inspected | # | 51 | 96 | 161 | 79 |
| 17 | Total number of different Alpha contractors | # | 4 | 3 | 8 | 4 |

Table 5, cont'd

***Yearly Inspection Performance Lines***

| No | Job | Unit | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | 9.3 | 9.5 | 9.8 | 9.5 |
| 2 | Oldest job surveyed | Years | 21 | 26 | 26 | 5 |
| 3 | Average age of jobs surveyed | Years | 6 | 8 | 9 | 3 |
| 4 | Age sum of all projects that never leaked | Years | 424 | 1,186 | 925 | 135 |
| 5 | Age sum of all projects that do not leak | Years | 518 | 1,786 | 1,406 | 168 |
| 6 | Percent of customers that would purchase again | % | 83% | 100% | 100% | 100% |
| 7 | Percent of jobs that do not leak | % | 100% | 100% | 100% | 100% |
| 8 | Percent of jobs completed on time | % | 100% | 99% | 100% | 100% |
| 9 | Percent of satisfied customers | % | 100% | 100% | 100% | 100% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 100% | 100% | 97% | 100% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 98% | 96% | 95% | 100% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 65% | 76% | 91% | 96% |
| 13 | Total job area (of job surveyed and inspected) | SQ | 42,500 | 122,347 | 74,754 | 30,357 |
| 14 | Total number of returned surveys / Num. of jobs surveyed | # | 126 / 170 | 234 / 348 | 160 / 267 | 62 / 65 |
| 15 | Total number of jobs inspected | # | 170 | 348 | 241 | 65 |
| 16 | Total num. of different customers surveyed & inspected | # | 69 | 141 | 171 | 7 |
| 17 | Total number of different Alpha contractors | # | 4 | 7 | 6 | 2 |

Table 5, cont'd

***Yearly Inspection Performance Lines***

| No | Job | Unit | 2009 | Overall |
|---|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | 9.7 | 9.3 |
| 2 | Oldest job surveyed | Years | 33 | 33 |
| 3 | Average age of jobs surveyed | Years | 11 | 8 |
| 4 | Age sum of all projects that never leaked | Years | 2,081 | 7,046 |
| 5 | Age sum of all projects that do not leak | Years | 2,999 | 10,207 |
| 6 | Percent of customers that would purchase again | % | 100% | 100% |
| 7 | Percent of jobs that do not leak | % | 99% | 100% |
| 8 | Percent of jobs completed on time | % | 100% | 98% |
| 9 | Percent of satisfied customers | % | 100% | 99% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 100% | 84% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 97% | 93% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 88% | 65% |
| 13 | Total job area (of job surveyed and inspected) | SQ | 156,922 | 588,871 |
| 14 | Total number of returned surveys / Num. of jobs surveyed | # | 283 / 390 | 1,307 / 2,000 |
| 15 | Total number of jobs inspected | # | 357 | 1,974 |
| 16 | Total num. of different customers surveyed & inspected | # | 101 | 988 |
| 17 | Total number of different Alpha contractors | # | 8 | 24 |

Table 6

***Dallas Urethane Performance Lines***

| No | Job | Unit | 2004 | 2006 | 2009 |
|---|---|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | 9.5 | 9.8 | 9.8 |
| 2 | Oldest job surveyed | Years | 18 | 20 | 23 |
| 3 | Average age of jobs surveyed | Years | 10 | 9 | 12 |
| 4 | Age sum of all projects that never leaked | Years | 283 | 241 | 303 |
| 5 | Age sum of all projects that do not leak | Years | 392 | 284 | 425 |
| 6 | Percent of customers that would purchase again | % | 100% | 100% | 100% |
| 7 | Percent of jobs that do not leak | % | 100% | 100% | 100% |
| 8 | Percent of jobs completed on time | % | 100% | 100% | 100% |
| 9 | Percent of satisfied customers | % | 100% | 100% | 100% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 53% | 100% | 100% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 93% | 98% | 100% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 72% | 18% | 100% |
| 13 | Total job area (of job surveyed and inspected) | SQ | 280 | 580 | 579 |
| 14 | Total number of returned surveys / Num. of jobs surveyed | SQ | 15,412 | 28,982 | 28,379 |
| 15 | Total number of jobs inspected | # | 38 / 55 | 32 / 50 | 35 / 50 |
| 16 | Total num. of different customers surveyed & inspected | # | 55 | 50 | 17 |
| 17 | Total number of different Alpha contractors | # | 44 | 34 | 25 |

Table 7

***Wattle & Daub Performance Lines***

| No | Job | Unit | 2003 | 2006 | 2009 |
|---|---|---|---|---|---|
| 1 | Overall Contractor Performance | (1-10) | 9.8 | 9.8 | 9.9 |
| 2 | Oldest job surveyed | Years | 27 | 24 | 24 |
| 3 | Average age of jobs surveyed | Years | 18 | 16 | 14 |
| 4 | Age sum of all projects that never leaked | Years | 785 | 518 | 447 |
| 5 | Age sum of all projects that do not leak | Years | 863 | 584 | 549 |
| 6 | Percent of customers that would purchase again | % | 100% | 100% | 100% |
| 7 | Percent of jobs that do not leak | % | 100% | 100% | 100% |
| 8 | Percent of jobs completed on time | % | 100% | 100% | 100% |
| 9 | Percent of satisfied customers | % | 100% | 100% | 100% |
| 10 | Percent of insp. roofs with less than 5% ponded water | % | 100% | 100% | 100% |
| 11 | Percent of inspected roofs with less than 1% deterioration | % | 98% | 100% | 98% |
| 12 | Percent of inspected roofs with less than 1/4" slope | % | 88% | 98% | 38% |
| 13 | Total job area (of job surveyed and inspected) | SQ | 19,489 | 20,535 | 15,077 |
| 14 | Total number of returned surveys / Num. of jobs surveyed | SQ | 993,953 | 862,471 | 768,945 |
| 15 | Total number of jobs inspected | # | 49 / 51 | 49 / 53 | 41 / 53 |
| 16 | Total num. of different customers surveyed & inspected | # | 51 | 53 | 53 |
| 17 | Total number of different Alpha contractors | # | 6 | 6 | 10 |

## Uses of Performance Information in the Procurement of High Performance Materials

There are various uses of performance information in procuring best value materials/systems:

1. Alignment of performance with a unique requirement.
2. Use of performance information instead of minimum technical qualifications.

3. Specification of a installed system with a quality control/risk management system that is more effective and efficient than a warranty.

## Using Performance Information to Align Requirement and Vendor Service

The performance information database and performance lines of contractors minimize the decision making of a client and their design representative. For example, if a client needed a high performance large roof system installed quickly, the client will likely pick contractor H from Table 4. Contractor H has 33 years maximum performance / 19 years average performance, and has a maximum installed roof size of 76,272 SF (largest roof.) They also have no currently leaking roofs, their performance rating is 9.8 (max is 10.0) and they have 100% customer satisfaction.

However, if the client had a smaller roof, over a historical library, where quality and the risk of leaking have to be completely minimized, the client would most probably select contractor E. The difference with contractor E is the Age Sum of Roofs that Never Leaked (ASRNL; add the number of years of all the roofs that never leaked of clients who were satisfied of roofs that never leaked for any reason.) It is important to realize that as roofs get older, they have a greater probability of leaking. Roofs will not last forever. Contractor E's ASRNL is 785 years. Contractor E has a performance rating of 9.8, 27 years maximum/ 18 years average rating, and 19,489 SF average roof size. Contractor E is a smaller contractor who has performed over a long period of time. When a contractor is smaller they tend to do better quality work. As they get larger, they get faster and do much larger work quicker. Contractor E will probably be more expensive than Contractor H, but for this client, Contractor E will be a better value.

## Using Performance Information in Place of Minimal Standards

The traditional way to specify a product is using minimal technical specifications. Many specifiers do not realize that minimum standards, such as ASTM, are created using manufacturer-provided data on their products, and the minimum ASTM specification is normally the lowest value of the participating manufacturers. The minimum ASTM standard has no documented or logical relationship to the expected length or level of performance. Even for a high performance product, in most cases, it is unknown which characteristic or combination of characteristics is most influential in providing the high performance installed product. Many of the current standards in the SPF industry originated with Kashiwagi (1999), who readily admits that at the time he set many of the SPF installation standards (minimum ½ inch SPF pass, one pass SPF roof system) he knew very little about the SPF mechanisms of performance and failure. He proposed the standards based on inspection results and practices of high performing contractors. Kashiwagi proposed a deductive approach to price based specifications:

1. Require the contractor and manufacturer to show documented proof of level/quality of performance and length of proven performance.
2. Require the contractor and manufacturer to provide their scope of work which includes a risk management plan and risk management report.
3. Require a risk management / quality control system for the length of the expected service period which includes every other year inspections by a third party.

4. Require a risk management plan and a weekly risk reporting system during the roofing project that identified all deviations on a project from the contractor's proposed baseline scope and schedule.
5. Require an ongoing performance assessment system of the manufacturer and their contractors.

The above are risk management principles. By definition, performance is risk management. Risk can only be determined once a level of performance is identified. If risk cannot be minimized, the client or end user will not have any way to mitigate their risk. It is safe to assume that if the manufacturer lacked the above risk management systems, they also have no way to manage the risk of nonperformance. Therefore, their cost would be higher, their profits lower, and they will become a manufacturer of commodity products who transferred the risk to the clients who bought the installed systems. The best way for manufacturers to transfer the risk to the end user would be to treat their contractors as their buyer/customer, and give them a warranty to deliver to the end users to minimize any liability. This is the traditional roofing delivery system which transfers the risk to the end user. A high performance manufacturer uses a specification in the price based environment which includes the risk management program before, during, and throughout the service period of the roofing system.

## Manufacturer's Risk Management System Case Study

The Dallas Independent School District (DISD) had used SPF roof systems in the past, but in 2000, had decided to discontinue any use of the system due to repeated nonperformance of the SPF systems (Smith, 2010). However, an introduction to the Alpha documented performance, the risk management approach of the Alpha system, and a best value procurement model which would ensure that high performance contractors would install the systems, convinced DISD to compete the Alpha SPF roof system against the more traditional built up roof (BUR) and modified bitumen systems in a best value Performance Information Procurement System (PIPS) test. After procuring three SPF roof systems out of ten roof projects based on performance, DISD decided to procure the Alpha system as a best value alternative system in their bond programs.

Over the next five years, DISD procured over 3M SF of the Alpha roofs (45 mil average) or a lower costing Permathane (35 mil average thickness) coated SPF systems. There were only four Alpha contractors competing for the work and when the 2005 Bond Program was initiated, and the four contractors had a difficult time meeting the demand. A non-Alpha (not measured, not using the performance documented Alpha system), also entered into the projects as an "or-equal", and DISD quickly saw the difference between the work, resulting in ensuring that all future SPF roof work is done by Alpha qualified contractors.

Some of the roof installations may have been done under suboptimal conditions due to the schedules of the roof installations. These conditions included inclement or cold weather and moisture saturated roofing insulation or decks. During the same time the SPF formulation was changed due to new requirements of minimizing the CFC blowing agent. With the radically increased work load caused by the DISD bond program demand for SPF roofing, the changing of the SPF formulation, and the constraints caused by the low price awards used by the general contractors (SPF roofing contractors were subcontractors) led to minimal SPF blistering (less than 1% of total roof areas.)

Table 8 shows the different Alpha contractors doing work at DISD. None of the contractors had more than 1% blistering, and the average blistering rate was 0.1%. The 71 roofs seemed to be installed correctly.

Table 9 shows the blistering areas on the DISD roofs. Even though the SPF blisters were minimal, DISD wanted the blistering repaired. The contractors initially requested the manufacturers (both Neogard and the SPF manufacturers) to assist in paying for the repairs. They contended that it was improper materials that caused the problem. Neogard resisted paying for the repairs due to an agreement with the SPF manufacturers that they would fund SPF blistering problems. At the same time the SPF manufacturers maintained that it was improper application that led to the blistering. PBSRG proceeded to inspect the roofs to identify the potential cause of problems.

Table 8

***Summary of DISD Alpha Contractor Results***

| Contractor | Number of Roofs | Total Roof Area | Average Age | Average Percent Blistered | Average Percent Repaired | Percent of Blisters & Repairs* |
|---|---|---|---|---|---|---|
| Alpha Contracting | 44 | 1,908,045 | 4.0 | 0.1% | 4.5% | 4.6% |
| Dallas Urethane | 2 | 192,000 | 4.4 | 0.1% | 0.4% | 0.5% |
| Longhorn | 3 | 108,500 | 3.9 | 0.1% | 0.3% | 0.4% |
| Phoenix1 | 20 | 765,360 | 4.9 | 0.3% | 3.2% | 3.5% |
| S & J Contractors | 2 | 49,500 | 2.9 | 0.6% | 0.5% | 1.1% |
| Average | 71 | 3,023,405 | 4.2 | 0.1% | 3.7% | 3.8% |

*This the sum of the average percent of blistered and repaired areas

Table 9 also shows the blistering results for the ten worst blistered roofs. The ten worst blistered roofs seem to have poorer application than the rest. Table 10 shows top ten most blistered schools.

Table 9

***DISD SPF Roof System Performance***

| No | Criteria | Unit | Overall | Top Ten Most Blistered |
|---|---|---|---|---|
| 1 | Percent of roof area blistered | % | 0.2% | 0.6% |
| 2 | Percent of blistered area with large blisters | % | 31% | 61% |
| 3 | Percent of roof area repaired | % | 3.7% | 2.3% |
| 4 | Average Blister Size | SF | 1.9 | 2.8 |
| 5 | Average Large Blister Size | SF | 7.7 | 10.8 |
| 6 | Average Repair size | SF | 62.7 | 20.6 |
| 7 | Minimum slit sample thickness | Mils | 23 | 14 |
| 8 | Average slit sample thickness | Mils | 35 | 29 |
| 9 | Average of Age | Years | 4.2 | 4.6 |
| 10 | Average roof size | SF | 42,583 | 37,033 |
| 11 | Total roof area inspected | SF | 3,023,405 | 370,330 |
| 12 | Number of roofs inspected | # | 71 | 10 |

Table 10

***Top Ten Most Blistered Schools***

| No | Criteria | Unit | Percent Blistered |
|---|---|---|---|
| 1 | Harlee ES | % | 1.2% |
| 2 | Conner ES - Middle Lower | % | 1.0% |
| 3 | Twain ES | % | 0.7% |
| 4 | Macon ES | % | 0.7% |
| 5 | Spence MS | % | 0.6% |
| 6 | Gill ES - Lobby & Cafeteria | % | 0.5% |
| 7 | Carver ES | % | 0.5% |
| 8 | Miller ES | % | 0.5% |
| 9 | Sequoyah Learning Center | % | 0.4% |
| 10 | Stonewall Jackson ES | % | 0.3% |

Figure 3 shows the percentage of blister contribution from the last 8 years. It seems as though there is no pattern. The authors assume that since there is no constant increase or decrease of blistering over time, blistering may be caused by the large demand in SPF roofing, resulting in a spike of blistering in 2005.

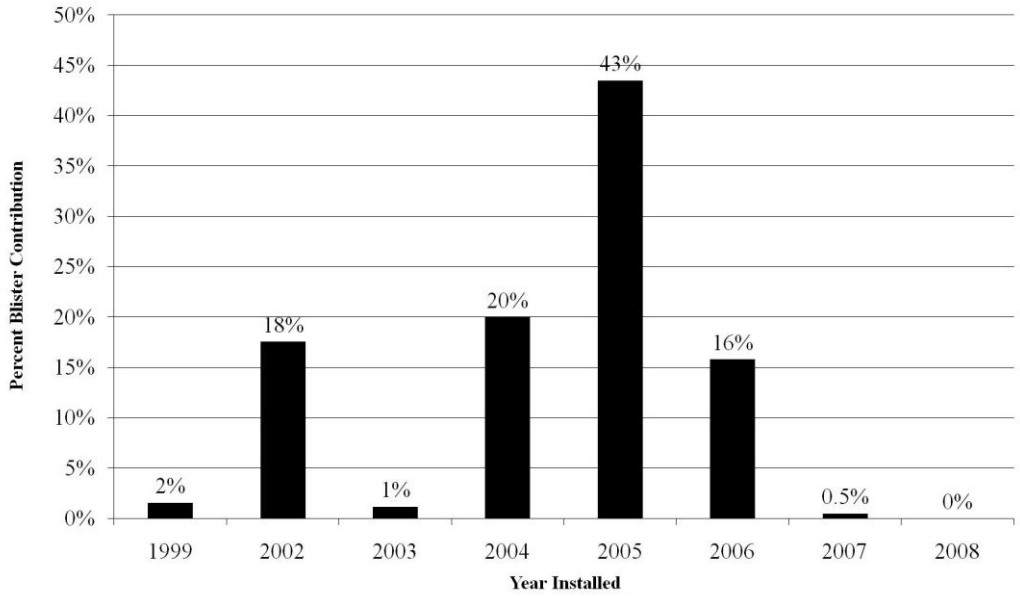


*Figure 3*: Percentage Blister Contribution by Year

Figure 4 shows that the percentage of blistering of roofs is higher in the first couple of years (1999 and 2002.) This verifies that in 2005, there was an increase in the amount of roof installed (Figure 5.)

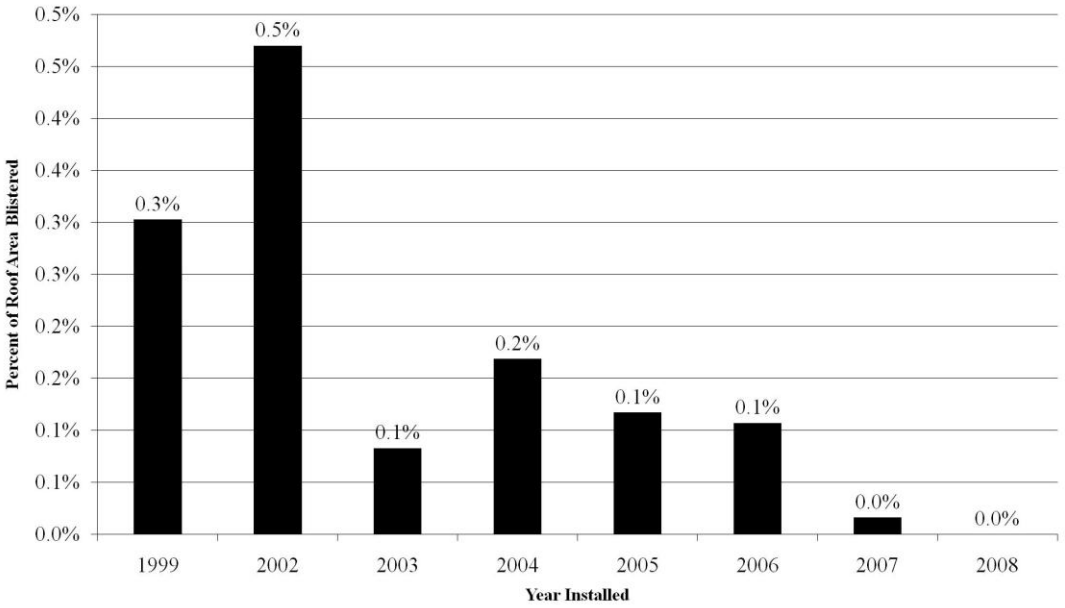


*Figure 4*: Percent Roof Area Blistered by Year

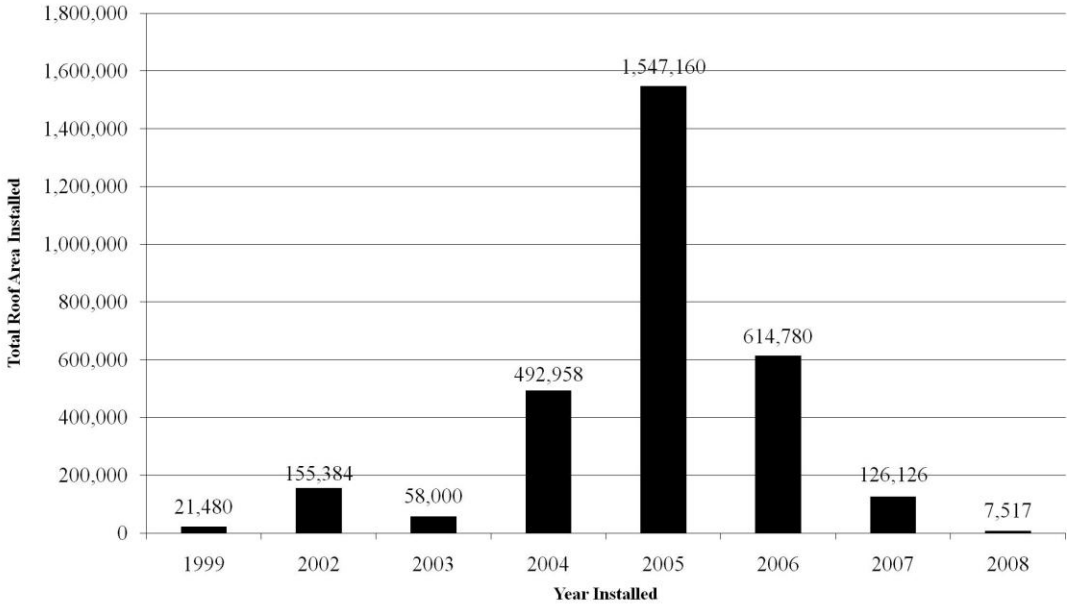


*Figure 5*: Roof Area Installed by Year

Figures 6 and 7 show that blister contribution and blisters/percentage of total roof area are high in October and December. Blister contribution is also high in August.

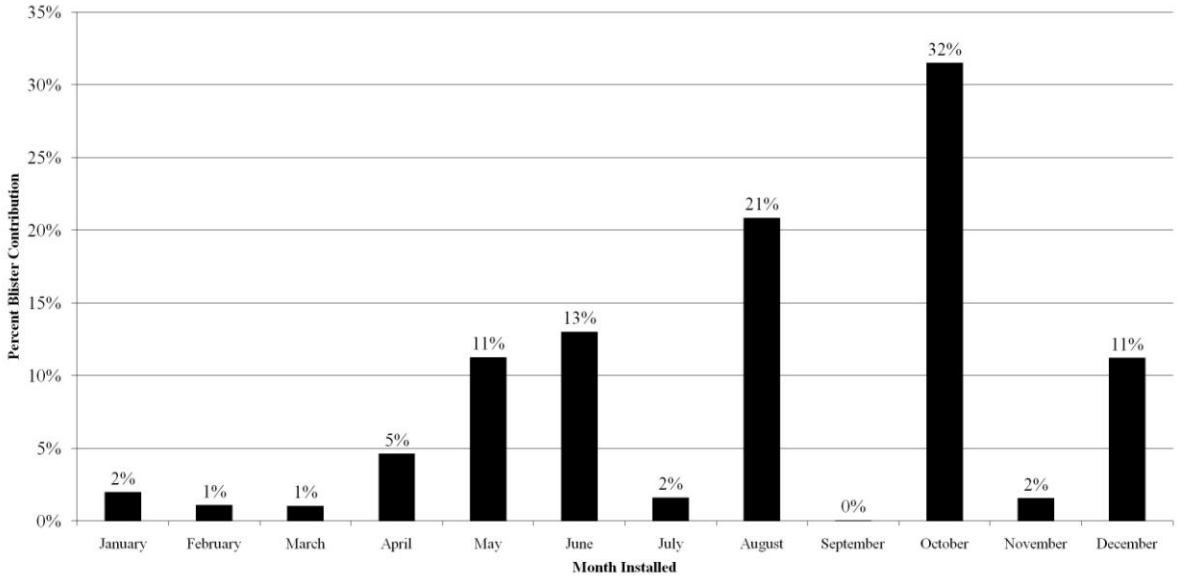


*Figure 6*: Percentage Blister Contribution by Month

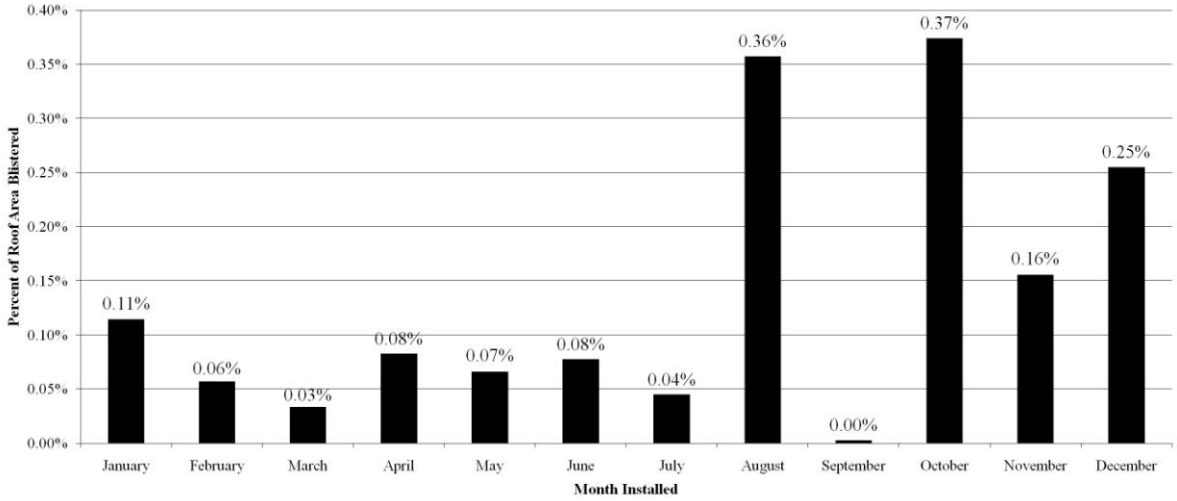


*Figure 7*: Percent of Roof Area Blistered by Month

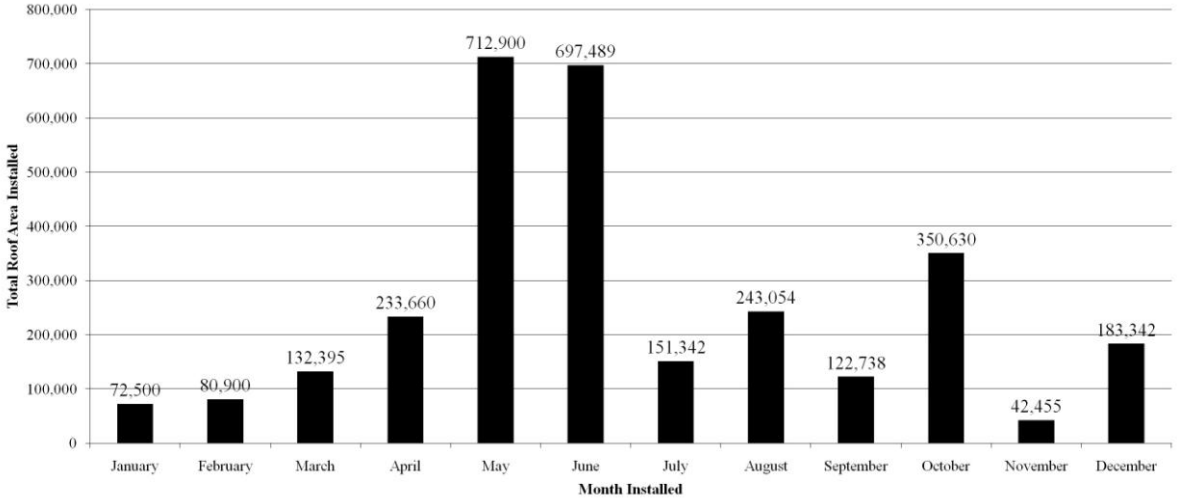


*Figure 8*: Roof Area Installed by Month

The data collection survey results showed that:

1. A large percentage of the blisters were on roofs installed during the colder weather, when SPF roof installation performance may be marginal.
2. The SPF roof system may be more difficult to apply, however, the data shows no substantial increase in blistering is caused by the transition of the SPF formulations.
3. Roofs with severe performance issues may have be related to a SPF manufacturer who had suboptimal SPF quality. It shows tremendous risk of using nonperforming materials.

The data also shows that the manufacturers were probably not responsible for the blistering due to poor materials. It seems as though the upswing in work resulted in contractors doing the work too quickly and not installing performance systems. The contractors also seemed to be pushing the envelope of doing work too late in the year. Because of the Alpha program and the performance information, the contractors agreed to fix their problems. The DISD representative, after reviewing the performance information, also agreed with the results of the performance survey. DISD has saved a minimum of $150,000 of repair costs because the contractors fixed their own problems. This is not the standard operating procedure for contractors to fix their problems at DISD roofs. It is even more interesting that a couple of the contractors who do not do a lot of DISD roofs, also fixed their blisters showing to the manufacturer that the contractors actually bought into the idea of performance, and were doing repairs because that is what a performer does. A major reason that the DISD roofing representative has stayed with SPF roof systems is the risk management/quality control system of the Neogard Alpha roofing system.

## Best Value Education

Neogard was the first construction manufacturer who perceived that the sponsoring Best Value education would assist in identifying high performance clients who would procure roofing systems in the best value environment. Presentations were made to many of the industry organizations in the U.S: International Facility Management Association (IFMA,) Project Management Institute (PMI,) Institute of Supply Chain Management (ISM,) American Society of Health Engineers (ASHE,) and the National Institute of Government Purchasers (NIGP) chapters to educate client representatives on value and performance. From the Alpha program sponsored client education, Neogard had tremendous successes with identifying the following clients who procured value based on documented performance information that resulted in a tremendous amount of success for Neogard's high performance products using high performance vendors (PBSRG, 2009):

1. 1997 ($2.8M) - The United Air Lines Maintenance, roofing and related waterproofing and flooring projects in 1997 and redoing the floors 11 years later: $2.8M.
2. 1998 – 2000 ($1.16M) - State of Hawaii roofs, Alpha system applications.
3. 1999 ($2.38M) - PECO Energy Facilities roofing.
4. 2002 ($1.9M) - Dallas Independent School District test case; roofing systems.
5. 2005 - Dallas Independent School District Bond program roofs (3 million square feet of Alpha and Permathane systems.)
6. 2005 - L3 facilities, 1.2M square feet, where an Alpha contractor switched over from unreliable polyurea fast-set coating to the more reliable Permathane Alpha coating system

due to documented performance information and Alpha system risk minimization capability.
7. 2005 ($0.35M) - US. Coast Guard direct bond roof Alpha system without the SPF.
8. 2005 ($1.46M) - US Army Medical Command roof at Fort Polk
9. 2006 - Schering Plough facilities in New Jersey used best value Alpha systems to install the Alpha system on their manufacturing plant roofs.
10. 2006 ($0.45M) - US Army Medical Command project roof at Dugway
11. 2009 ($1.6M) - Kansas Marine building envelope roof
12. 2010 ($0.5M) - US Army Medical Command Roof at Fort Rucker: 70,000 SF

All the above clients were influenced by the documented performance, and risk management program. The high number of projects over the ten years of the best value and Alpha program assisted in development of the Best Value program at PBSRG.

## Moving Forward: Risk Management Program

Contractors who were required to fix their SPF roof problems at DISD reacted in the following manner:

1. Contractors should be required to fix their problems in a performance based system.
2. Pricing of future roof projects will consider the risk caused by general contractor's schedule requirements and the potential for moisture in the existing deck.
3. Contractors will be much more conservative of meeting the minimum environmental requirements required by SPF application.

The majority of contractors at DISD also proposed that they would inspect the roofs more often than the Alpha program requirement of every other year, especially the roofs that may have more issues. This contractor behavior is one of the objectives of the Alpha program:

1. Contractors reinspect roofs at least once a year.
2. Contractors give the client proactive updates on their roof installations.

Manufacturers and contractors have a difficult time being proactive in addressing risk. Neogard is the only manufacturer in the SPF industry who has a proactive performance based methodology in minimizing the risk of nonperformance once roof systems have been installed. However, the best value risk management system which assists the contractors to minimize the risk before and during installation has yet to be successfully implemented. The latest change in the Alpha program is to have the following implemented in the Alpha specification and roof installation process:

1. A risk management plan which is agreed to by client, contractor, and manufacturer before the notice to proceed is issued on the roof project.
2. A weekly risk report, which tracks all potential risks and deviations to a roof installation during the duration of the project.

## Risk Management Plan

The risk management plan is a plan that minimizes the risk that the contractor does not control to include:

1. The expectation of the client which exceeds the contract technical scope.
2. The risk to the performance of the roofing system that was poorly defined or not included in the project scope.
3. The reaction to uncontrollable elements such as weather, SPF material quality, equipment malfunctions.
4. Concerns of the client and general contractor including timing, project schedule, interface between roof and other building elements.

The risk management plan requires the following:

1. A meeting between all participating parties before the project starts to identify all risks and concerns.
2. The contractor's method of managing and minimizing the risks and concerns.
3. The approval of all other parties of the risk management plan.

The risk management plan then becomes the last page of a weekly risk report. The weekly risk report includes the following elements and is submitted once a week to the roofing manufacturer's representative, the client's project manager, the procurement agent, and the general contractor:

1. A list of all contacts of the major participants with their contact information.
2. A milestone schedule and the actual schedule.
3. A tracking of all change orders/modifications on the project that causes a deviation of time or cost.
4. A short explanation of every risk, and the management of the risk that leads to the modification.
5. A printout status report sheet that captures the status of the project.
6. An updated risk management plan.

Each item is on its separate page on the spreadsheet. The spreadsheet is managed by the contractor, updated weekly, and sent to the critical participants on the project. Clients such as the University of Minnesota and the U.S. Army Medical Command, have another spreadsheet that collects individual project risk reports and automatically analyzes the risk information and produces an overall Director's Report of the riskiest projects. This Director's Report can handle up to 300 different projects without much effort. The use of the Director's Report is a method to manage a tremendous amount of projects with very little effort, forcing contractors to be accountable for the projects. The risk management system using the risk management plan, the weekly risk report, and the Director's report, has minimized the amount of cost deviations of projects by 170% for the U.S. Army Medical Command. A manufacturer with high performance product/systems, and using a risk management program that includes tracking project performance information, a risk management plan, weekly risk report, and a Director's Report, can offer the best value to customers requiring roofing system assistance.

## Conclusion

Neogard has successfully identified itself as the manufacturer of the highest performing elastomeric coating for a sprayed polyurethane foam (SPF) roofing system in environments requiring durability and impact of hail environments. They have implemented a performance based program that measures the performance of not only their coating, but the contractors installing the SPF roofing system to optimize the performance of the installed SPF system. The performance based contractor program is the only performance based program in the construction industry, where contractors are allowed in and eliminated based on performance requirements of end users/facility owners. The end user customer satisfaction includes high percentages of roofs not leaking (98%) and customers satisfied (98%). Neogard has also moved the performance measurements into the areas of flooring, wall coatings, and waterproofing.

Neogard has used the construction industry structure (CIS) business approach to sell its products in all three construction industry environments. They have set the Alpha program in the best value environment, where they capture the high performance resulting from alignment of the high performing end user, manufacturer product, and contractor. They then use the marketing of high performance numbers and distribution of products in the price based marketplace to minimize liability and the risk of nonperformance. They also use the performance information in the negotiated or sole source environment to ensure the clients that they are getting the highest performance. In all three environments, they should use the weekly risk report to minimize risk and liability.

Neogard has tested out their performance based contractor program on a large client, the Dallas Independent School District (DISD.) DISD and Neogard have both benefited by high performing contractors fixing over 30,000 SF of blisters (minimal $150,000.) Some of the contractors do not have DISD as their major clients, and these contractors also fixed their problems. Currently the 80 SPF roofs at DISD do not leak and are trouble free.

## Recommendations for Further Research

The authors make the following recommendations to optimize Neogard or other manufacturer's high performance products/installed systems:

1. Study the use of performance information to determine "or equal" products instead of minimal technical measurements, physical properties or standards.
2. Research the possibility of requiring manufacturers of construction products to minimize risk created before, during, and after installation with a risk management system based on performance information instead of warranties.
3. Study the proposal to require manufacturers and contractors to constantly measure the performance of their products in terms of customer satisfaction, not leaking, protection of structures, performing without defects, and the capability to respond to issues if they occur.
4. Study the risk management programs of manufacturers and contractors to document deviations to product installation and scope in terms of concerns, costs, time, and expectations.

## References

Goodridge, S., Sullivan, K. and Kashiwagi, D. (2007) "Case Study: Minimization of Best Value Issues in the Procurement of Construction Services at the City of Miami Beach" COBRA 2007 - Construction and Building Research Conference, Georgia Institute of Technology, Atlanta, GA, USA, CD-T68 (September, 6, 2007).

Kashiwagi, Dean T. (2009). *Best Value*. Tempe, AZ: Performance Based Studies Research Group (PBSRG).

Kashiwagi, D.T. (1996). Performance issues of sprayed polyurethane foam roof systems. *Professional Roofing,* 18-22.

Kashiwagi, D. (2009) *Risk Management Model: How to Implement one.* Unpublished manuscript.

Kashiwagi, D. T. and Pandey, M. K. (1998). Hail Resistance and Performance Analysis of Elastomeric Coated SPF Roof Systems. *RCI Interface,* Vol XVI No. 7, 10-19.

Kashiwagi, D.T. and Pandey, M.K. (1996), Hail Resistance of SPF Roof Systems, Performance Based Studies Research Group, Tempe, AZ.

Kashiwagi, D. T. and Pandey, M. K. (1997) Impact Resistance of Polyurethane Foam Roofs Against Hail Journal of Thermal Insulation and Building Envelopes Vol. 21, pp. 137-152, October

Kashiwagi, D.T. and Pandey, M.K. (1996). Oversize Hail Resistance Test of Elastomeric Coated Sprayed-In-Place Polyurethane Foam (SPF) Roof System, Performance Based Studies Research Group, Tempe, AZ, ISBN: 1-889857-11-4

Kashiwagi, D.T., Sullivan, K. and Badger, W. (2006) "Future Research Model of the New University" International Conference in the Built Environment in the 21st Century (ICiBE 2006) Kuala Lumpur, Malaysia, pp. 463-473 (June 13, 2006).

Kashiwagi, D. T. and Tisthammer, T. (2002) Information Based Delivery System for Sprayed Polyurethane Foam on Roofing Journal of Thermal Envelope & Building Science (26) 1 pp. 33-52, July

Pauli, M., Sullivan, K., and Kashiwagi, D. (2007). "Utilization of Risk Management to Show Value and Increase Competitiveness." *Cobra 2007 Conference*, Georgia Tech Global Learning Center, Atlanta, GA, CD Track 59 (September 5, 2007).

PBSRG (2009) *Performance Based Research Group Internal Research Documentation.* Arizona State University. Unpublished Raw Data.

PBSRG (2008) Overview: PBSRG documented performance. Accessed on April 1, 2008 at http://www.pbsrg.com/overview/pline.htm

Smith, M. (2010). Interview with the author on 10 December 2009. Tempe, AZ.