Best Value Case Study for Cold Storage Facility in Miami, Florida

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A cold storage facility had been reroofed in 2003 (investment of $600,000) that required the removal of existing insulated roof and replaced with a 20 year modified bitumen roof. After six years, the facility posed a safety hazard due to the ice formations inside the cold storage facility. The source of the problem was not known. The traditional process of using a professional designer, a certified contractor, receiving a manufacturer's warranty, and having the roof inspected by the local government inspector could not assist the owner and the FM resolve the complex problem. The facility manager (FM) decided to utilize a non-traditional Best Value (BV) Performance Information Procurement System (PIPS) to identify and resolve the problem. The main difference of the system is that the best value vendor and not the owner determines the final scope. This paper documents the BV PIPS approach and the resulting performance. An inspection five years later verified the performance of the Best Value approach and showed the value of the installed sprayed polyurethane (SPF) roofing system.

Keywords: best value, roofing, energy savings, performance

Introduction

In the fall of 2009, the project/facility manager for the cold storage facility at 555 N.E. 185th Street, Suite 107, Miami, FL 33179 Fort Lauderdale, Florida, contacted the Performance Based Studies Research Group (PBSRG) to assist with a very difficult facility management (FM) issue. The cold storage facility had to maintain an inside temperature below -10 degrees Fahrenheit. In the summer time, Miami has temperatures over 100 degrees and average humidity of 73%.
The cold storage facility had been reroofed [investment of $600,000] six years earlier [2003] with the requirement of removing the existing insulated roof, and installing a new 20 year modified bitumen, insulated roofing system. The expectation of the facility manager and the tenant was a trouble free cold storage facility for the next 20 years.

After six years, without noticeable deterioration on the exterior roofing system, the cold storage facility was experiencing widespread and dangerous ice formations [as large as five feet in length]. The ice formations caused a safety hazard as well as a potential inefficient electrical usage. The cause of the problem was not immediately known, however, the facility manager representing the building owner along with the tenant proposed that a new roof may be required.

The owner had just spent $600K six years earlier with the expectation of a minimum 20 year roof performance, and now was facing another minimum $600K investment [probably more]. The owner also had intentions of selling the property which could only be done if the cold storage problem was rectified. The FM was facing a hitch that is a property manager/FM's worst nightmare. It was an unanticipated problem that requires a huge financial investment, after the

owner had previously invested to solve the same problem [roofing/waterproofing problems makeup 80% of all building/facility problems.] Regardless of who is at fault, the facility manager was now working with a more hostile owner.

The tenant moved into the facility at 555 N.E. 185th Street, Suite 107, Miami, FL 33179 Fort Lauderdale in July 2008. The tenant runs a storage and delivery of frozen foods to the cruise ship business operating out of Miami. They moved into the facility in 2008 with the understanding that the facility was in good working order. The ice formations in the cold storage caused a safety issue, a cost issue for the client [the tenant was paying the electric bill] and a customer dissatisfaction issue.

The FM was facing a problem that was not well understood and which had gotten past a professional designer, the county inspecting office, a certified roofing contractor, a manufacturer of roofing systems and their own FM/engineering group. The owner wanted the problem solved and was contemplating suing the previous roofing contractor who installed the previous roof. The engineering firm that wrote the roofing specification and accepted the completed roof would also be involved in any roofing non-performance issue. The county inspector would also be complicit if the roof was not properly installed. The FM had to identify the problem, have an explanation of why the problem occurred, identify who was responsible for the problem and have the nonperforming parties solve the problem and have a simple and clear explanation to the owner that would convince them to pay to fix the problem the second time [which was not solved by the appropriate parties the first time]. The owner's FM no longer had confidence in the traditional professional engineering service or the roofing contractors.

The FM was introduced by a best value expert, Denise DiGruccio, to the Best Value approach to solving facility problems. The process was called the Best Value [BV] Performance Information Procurement System [PIPS]. The last couple of decades have revealed a poor documentation of performance information in the construction industry (Cahill and Puybarand, 1994; CFMA, 2006; Flores and Chase, 2005; Egan, 1998, Davis et. al. 2009) Many researchers have suggested different types of systems in attempt to change this trend (Hillson, 1997; CII, 1995; Gibson et. al., 2006; Hamilton, 1996; Sullivan, 2010; Davis, et. al., 2009; Sweet, 2011). The BV PIPS is different from the traditional delivery systems because it utilizes expertise of industry experts and minimizes the management, direction and control [MDC] of the vendors. An expert can think in the best interest of others, identify the risks involved in the project and can pre-plan. Instead of specifying what the expert vendor must do, it identifies what the owner "thinks" is the problem and the general intent of the owner [to solve the perceived problem]. Because the owner is not an expert, they will utilize the expertise of the expert vendors to solve the problem. The owner is not liable to definitively know either the problem or the solution as they are the non-experts. It then allows the expert vendors to compete based on their ability to identify and solve the problem with their accompanying prices [what, why, how, and what it will cost]. The prioritized best value expert vendor based on expertise and cost then clarifies in detail what they will do to meet the expectations of the client.

In the BV PIPS approach, the expert vendor is not identified solely by profession, education, trade or length of experience, but by their capability to identify and fix the client's problem. The expert is the vendor who can and will fix the problem. They are the entity who can do it for the least cost and the give the owner the highest value. It is well documented that the product specifications

using minimum standards, have no direct correlation with the performance of an installed system (Kashiwagi, 1996).

Problem

The facility was reroofed in 2003 to eliminate problems with leaking and ice formation. The specifications were done by an engineering service representing the client. After six years [2009], ice continued to form in the cold storage facility as shown in Figure 1, and the facility management representative perceived that the problem had to be rectified even though it was a recently installed roofing system [six years previous].

Figure 1: Ice Formations

The FM group representing the owner faced the following problems:

1. They had previously hired an engineering firm to analyze and solve the problem with ice forming in the cold storage facility before roof was installed in 2003. The owner would be very hesitant to hire the same or another engineering firm.
2. They hired a roofing contractor who reroofed the facility installing roof according to instructions of the engineering firm's specifications. The roofing contractor claimed they met the requirements of the specification and was not liable for any damages.
3. The roofing manufacturer gave no assistance even though a warranty was issued.
4. The installation of the new roof in 2003 was inspected and approved by the Dade County inspectors.
5. The roof system installed in 2003 did not perform as ice had formed in the cold storage facility.

The legal and professional protection of the delivery of the roofing system [professional engineering firm, the government inspection group, the manufacturer's warranty, the certified roofing contractor, and the engineering specifications] had failed to protect the owner. The FM was now requesting the owner to pay an additional $600K+ to pay for a new roof of which the problem [source of the ice formations in the cold storage facility] with the existing roof system was not clearly identified.

Solution

The FM made a decision to utilize the Best Value (BV) Performance Information Procurement System (PIPS) which utilized the expertise of the expert roofing vendors to minimize risk. The owner identified what they perceived the problem was [ice formation within the cold storage facility] and used the BV PIPS to have expert vendors more accurately identify the problem and solutions. The FM then used the BV PIPS structure to identify the most capable and expert vendor. The best value vendor's solution would then define the final project scope.

This is a case study test of the FM using the non-traditional BV PIPS system to solve their facility problem. Instead of having the owner hiring an engineering firm to identify the problem and solution and then manage, direct and control [MDC] the lowest priced vendor, the client used the BV PIPS system to identify the expert vendor and utilized the expert vendor's solution to solve the problem. This is counter to the traditional system where the owner utilizes their own professional engineering firm to identify the problem and then use MDC in the form of engineering specifications and standards to MDC the lowest priced vendor to do the work.

Methodology

This paper will discuss the conceptual differences of the BV PIPS delivery system. It will then go through the steps of the BV PIPS steps that facility manger (FM) used to identify the BV vendor and its results. Five years later, the performance was again determined based on roofing performance and cost saving based on actual energy savings. This Post Occupancy Evaluation (POE) method where a finished product is evaluated to measure the quality is currently being implemented in the industry to measure quality (Wicks and Roethlein, 2009). Visual inspections and condition assessments procedures are also used in the industry to determine performance (Bailey & Bradford, 2005; Coffelt et. al., 2010).

In the previous installation of roofing system, the owner hired a professional engineer who decided what the problem was, what had to be done, and how to do it [MDC], and ensured that the expert roofing contractor followed their instructions. The installation was also inspected by the county inspector. After six years, the FM, the facility owner and the tenant could clearly observe that "something was wrong" with the formation of five foot ice stalagmites in the cold storage facility. No party [engineering firm, certified roofing contractor, roofing manufacturer or government inspector] volunteered to be legally or professionally accountable for the nonperformance. The owner would have to have an expert identify what was wrong and then attempt to get a mediated settlement. In this traditional system, it is very difficult to assign accountability (Sullivan and Michael, 2011). Multiple models and strategies have been proposed to increase accountability in different areas of construction (Sohail and Cavill, 2008; Cavill and Sohail, 2005; Chen, 2013)
This paper is a natural comparison of results of the traditional delivery of service and the innovative BV PIPS delivery system. The previous roofing system was delivered using the traditional management, direction and control [MDC] methodology. It resulted in poor performance and limited accountability and responsibility between the party who designed the solution, the party who installed the solution, and the party who inspected and ensured the system was installed correctly.

In the new BV PIPS system, vendors compete to identify the highest level of expertise, and the expert vendor identifies what to do and how to do it. The owner's management, direction and

control [MDC] is replaced by the utilization of the expert's expertise. In simple terms, if someone is an expert, no other entity should need to direct them on what to do. Due to the single source of expertise, the vendor is responsible for solving the problem. The single source of responsibility minimizes decision making and creates transparency.

Best Value Performance Information Procurement System [PIPS]

The BV PIPS system was discovered by Dean Kashiwagi in 1991, and is currently being tested and developed by Performance Based Studies Research Group [PBSRG] at Arizona State University. BV PIPS is a licensed system by AZ TECH, the licensing arm of Arizona State University. The BV PIPS system has the following conceptual differences from the traditional systems [Kashiwagi, 2014]:

1. Utilizes expertise to lower cost and add value.
2. Identifies expertise as the only factor that can minimize risk of nonperformance.
3. Identifies warranties, specifications and standards as inefficient in minimizing risk.
4. Identifies that attempting to manage, direct and control non-expert vendors is inefficient and costly.
5. Identifies if you ask a vendor to describe the problem, how they know that it is the problem, how they know they can solve the problem using performance metrics and by recognizing natural laws the differentiate experts from non-experts, the risk of nonperformance is minimized drastically.
6. Methodology that a non-expert can identify an expert vendor and utilize the expertise to lower cost and risk.

The BV PIPS can be implemented in different variations. It includes a competitive selection phase, a clarification phase and an implementation or execution phase. The contract is signed after the clarification phase. The competitive selection phase is where value is identified by the comparison of values and prices. The best value is always the "best value provided for the lowest price" and is relative. The best value is always the best value of a group of proposed vendors. Once the best value is identified in the competitive selection phase, the best value vendor must identify in detail what they are going to do in the clarification phase. This detailed proposal [clarification] is then put into the contract along with the vendor's price. The contract is signed and the contractor delivers their solution in the execution phase.
The characteristics of the BV PIPS include:

1. The owner identifies a problem [ice formation inside the cold storage facility]. There is no clear identification of how the water or vapor penetration into the cold storage. Regardless of the owner's lack of knowledge of the problem and the solution, the expert vendor is required to solve the problem of the ice formations.
2. The competing contractors respond to the problem by providing proof of their expertise and a price. The proof of expertise can be determined in many different ways. It normally includes past performance metrics on similar projects. The FM utilized performance metrics of Neogard's Alpha Program. The Alpha program is a program sponsored by Neogard, a manufacturer of high performance urethane coating systems [often utilized with a layer of sprayed polyurethane foam [SPF]. The Alpha program utilizes performance metrics which

show the relative performance of high performance contractors (Kashiwagi et. al. 2010). A short explanation will be given later.
3. The contractors were asked to propose their solutions.
4. The owner utilized an interview as a very key component of the competition. The owner defined an expert by several characteristics of the Alpha program that will be discussed later.
5. The BV PIPS system then identified the expert based on the performance metrics and the prices.
6. The owner then utilized a "clarification period" where the best value vendor clarified [clearly identified their solution] in detail. The solution then shaped the contract.
7. The best value vendor then installed their solution and the owner rated their installation.
8. There were several change orders in the contract due to additional information once the pre-existent conditions were identified by the best value vendor.
9. The performance of the contractor during their roof installation is rated by the owner.
10. Over time, the solution can be analyzed for performance [not leaking, no ice formation and low energy bills due to the stopping of ice formation in the cold storage facility.] This performance may override any perceptions that they have during the roofing installation.

In the process, the client was instructed to minimize their decision making. Decision making increases risk. If all the vendors look alike to the client and no vendor differentiates themselves, the BV vendor is the lowest costing vendor. Expert vendors show their high performance on previous similar work through the use of performance information. They will show confidence on the subject project by addressing the needs and concerns of the client. If the BV PIPS overall scores are close, the owner/buyer is encouraged to go with the lower priced option. If the best value vendor is more expensive [by a significant amount], the best value vendor must clearly identify why they are more expensive.

Competitive Selection Phase

Four contractors submitted proposals for the reroofing project. One of the contractors (Vendor B) proposed two different types of systems, a SPF roofing solution (Vendor B1) and a single ply TPO solution (Vendor B2) [inexpensive option]. The criteria for the selection phase were taken from the Best Value PIPS approach and the Neogard Alpha program (Kashiwagi, 2009). This included:

1. Customer satisfaction of previously installed roofs. This included roof sizes, roof ages and roof performance information [leak history].
2. Calculated "sum age" metric [of all roofs that never leaked]. This is the total years of all roofs that never leaked and where the client was satisfied.
3. Proposed cost.
4. Rating of an interview of the vendor's project manager for the subject project.

The client identified cost and interview rating as the highest rated criteria (see Table 1). The vendors would have to score well in the cost criteria [lowest cost] and interview [highest interview score]. The vendors' articulation of the problem and solution and their ability to show the characteristics of an expert vendor on a very controversial and complicated project in the interview, was very important to the selection committee. The cold storage facility problem was unique in that it was in a very humid and hot environment. The source of the problem was not known. The tenant could not afford to shut down or move their operations to another facility during the

construction. This made the vendor's temperament, understanding and capability to work around the client's operations very important. The cost was important because the building owner had to be convinced to invest the estimated $600K+ for the project. Unless one of the options was dominantly better, it would be hard to convince the owner to pay more the second time to fix the same problem.

Table 1

Weightage Breakdown

Selection Criteria	Selection Weights
Proposed Duration	10
Proposed Total Cost	43.35
Sum of age of all the jobs that do not leak	6.66
Past Performance	3.33
Average age of all the jobs	3.33
Average roof size	3.33
Interview Rating	30

Table 2 compares the proposal information for 4 contractors that bid on the project. Vendor B was immediately at risk because they submitted only one past project and the average age of jobs on like projects did not show performance and were the lowest when compared to other vendors. Moreover, the interview scores for Vendor B showed a lack of acceptability by the client's rating team [1.1 out of a maximum of 10.0]. By observation of the vendor's price submittal, the vendor's price was the highest price for the encapsulated insulated roof system. To compete with the other vendors, vendor B tried to substitute a lower costing roofing system [lowest costing of all roofing systems]. Vendor B also submitted only one previous roof installation, and the installation had just been installed [no past performance]. The FM also stated that Vendor B had verbally harassed the FM, and tried to harass the owner as well throughout the process. When the FM would not consider this vendor, the vendor went above the level of the FM to attempt to convince the owner that their FM was making a mistake and should award them the project.

By observation of the information, the competition was down to four potential vendors. Vendor A and Vendor E were the only ones that included the addition of wall insulation in their proposal. Other vendors proposed only to insulate the roof. Vendor A and E had the highest interview score. However, Vendor E was over $100K higher in price than Vendor A [18% higher cost]. Vendor D had the highest past performance of all the vendors. However, Vendor D's price was also high [$60K or 10% higher]. Vendor D was not offering the wall insulation. Neither Vendor E nor C was able to override the huge advantage of price and interview rating score of Vendor A.

Table 2

Proposal Information

Criteria	Vendor A	Vendor B1	Vendor B2	Vendor C	Vendor D	Vendor E
Proposed Duration (days)	85	60	50	30	60	60
Proposed Total Cost ($)	$570,846	$798,960	$577,824	$596,000	$629,574	$685,379
Sum of age of all the jobs that do not leak	19.1	0.5	0.5	84.5	264.0	14.7
Past Performance (out of 10)	10.0	9.9	9.9	9.5	10.0	9.6
Average age of all the jobs (Yrs.)	1.5	0.5	0.5	6.5	14.0	3.7
Average roof size (SF)	60,244	40,669	40,669	12,080	60,595	159,988
# of Surveys	14	1	1	13	19	4
Interview Rating (out of 10)	9.39	1.11	1.11	4.94	4.83	6.28

The interview results of Vendor A made a significant impact on the selection committee. When compared with the other vendors, Vendor A was the clear choice of the selection committee. When calculated the final prioritization the lowest price [which the selection committee did not see until the end] and the interview rating made Vendor A the clear choice.

Table 3

Normalized Data

Criteria	Vendor A	Vendor B1	Vendor B2	Vendor C	Vendor D	Vendor E
Proposed Duration (days)	3.53	5.00	6.00	10.00	5.00	5.00
Proposed Total Cost ($)	43.35	30.97	42.83	41.52	39.31	36.11
Sum of age of all the jobs that do not leak	0.48	0.01	0.01	2.13	6.66	0.37
Past Performance (out of 10)	3.33	3.29	3.29	3.17	3.33	3.21
Average age of all the jobs (Yrs.)	0.35	0.12	0.12	1.55	3.33	0.88
Average roof size (SF)	1.25	0.85	0.85	0.25	1.26	3.33
Interview Rating (out of 10)	30.00	3.55	3.55	15.78	15.43	20.06

Each normalized data [Table 3] for the vendor was multiplied by the weight breakdown for the respective selection criteria to calculate the total points for each vendor. The total point's breakdown for each vendor is shown in Table 4.

Table 4

Total Point Breakdown

Criteria	Vendor A	Vendor B1	Vendor B2	Vendor C	Vendor D	Vendor E
Proposed Duration (days)	3.53	5.00	6.00	10.00	5.00	5.00
Proposed Total Cost ($)	43.35	30.97	42.83	41.52	39.31	36.11
Sum of age of all the jobs that do not leak	0.48	0.01	0.01	2.13	6.66	0.37
Past Performance (out of 10)	3.33	3.29	3.29	3.17	3.33	3.21
Average age of all the jobs (Yrs.)	0.35	0.12	0.12	1.55	3.33	0.88
Average roof size (SF)	1.25	0.85	0.85	0.25	1.26	3.33
Interview Rating (out of 10)	30.00	3.55	3.55	15.78	15.43	20.06
TOTAL POINTS (out of 100)	**82.30**	**43.79**	**56.64**	**74.41**	**74.32**	**68.96**

Table 5 breaks down Vendor A's proposal. As stated before, Vendor A also proposed to encapsulate and insulate the walls of the facility. They assumed that vapor penetration was a source of part of the problem causing the ice buildup in the cold storage. This assumption showed their expertise, and would result in the tremendous performance of their finished installation. The Selection of Vendor A in the best value approach resulted in the lowest price for the best value. Table 5 is a breakdown of Vendor A's proposal.

Table 5

Bid breakdown for Vendor A

Criteria	Total Cost
Mobilization	$8,500
Permits & Engineering	$5,000
Polyurethane Foam & Coating Materials	$228,388
Existing Roof Removal	$65,961
New Roof Application	$143,227
New Wall Application	$106,320
Clean up	$5,000
Demobilization	$8,500
TOTAL BASE COST	**$570,846**
Change Order 1	$337,309
Change Order 2	$208,860
Additional Service 1	$67,500
TOTAL AWARDED COST	**$1,184,515**

After awarding the project to Vendor A, destructive testing of the roof revealed the following:

The contractor who installed the existing roof did not do a tear off of the existing insulation as directed. Instead, they installed an insulation board over the existing insulation system, fastening the board with roofing screws. Their installation created more penetrations through the existing

steel deck. The existing insulation had to be removed to the deck due to saturation and the formation of ice on the metal roof deck. Change order #1 was to completely remove and dispose all existing roof systems on Section 8 upper roof (22,035 SF) down to the existing metal roof deck and install the polyurethane foam to the existing metal ribbed deck.

When Vendor A removed the existing roofing systems and insulation, they found that the metal deck was riddled with rust almost like "swiss cheese". Their guess had been right and vapor had penetrated into the roofing insulation and created an ice situation on both sides of the freezer ceilings and walls. Change order 2 was to remove and properly dispose off the unsafe steel roof decking from Section 8 upper roof and Section 9.

Vendor A realized that the tenant did not want to shut their operations while the roof was being removed and installed. Their team realized that the cold storage room could be separated by an insulated wall. The insulated wall would create two compartments which could utilize the two existing chiller units, essentially creating two cold storage compartments. The newly installed insulated wall would allow the tenant to not have to transition to another facility while the new roof was being installed. The two compartments would allow the roofing Vendor A to reroof one compartment at a time, while the tenant conducted operations out of the other compartment.

The total cost of the project was $1.2M. The owner entered with the previous roofing contractor and was able to recoup some of the costs of damages caused by the improper application. However, due to the designer inspecting the roof and the roof passing inspection, it was difficult to fully recover for damages.

One of the main components of BV PIPS is the weekly risk report after signing the contract. The weekly risk report is a communication tool for the owners, contractors and other stakeholders that track cost and schedule deviations. The major sections in the weekly risk report are milestone schedule, risk minimization plan, risk sheet that identifies who caused the risk, the solution to the risk and time and cost deviations. Weekly risk report creates transparency and documents the on-going status of the projects.

Vendor A was not familiar with the weekly risk report and did not utilize it to its full extent. The FM and the owner gave Vendor A lower performance ratings due to the misunderstanding that the project did not come in on time and there was not a weekly risk report that kept them abreast of the unforeseen risks on the project. However, after analyzing that all of the risks were due to the client and not the contractor in Table 6, it can be seen that Vendor A performed to the highest levels. The FM has now scored the best value contractor with a10 out of 10 rating due to no schedule and cost impacts by the contractor.

Table 6

Project Risks

Source of Risk	Total # of Risks	Schedule Impact (Days)	Cost Impact ($)
CONTRACTOR IMPACT - General Issues	0	0	$0
DEALER IMPACT - Sub/Supplier Issues	0	0	$0
DEALER IMPACT - Oversight of Design	0	0	$0
ARCHITECT / DESIGNER IMPACT	1	0	$24,485
CLIENT IMPACT - Scope Change / Decision	2	63	$0
CLIENT IMPACT - Contractors (GC, Mech., etc.)	2	75	$0
CLIENT IMPACT - Contract / Payment	1	30	$0
CLIENT IMPACT – Other	0	0	$0
Impact of unforeseen conditions	5	188	$610,000

The cost deviation of $24,485 was due to the structural problems. In the tear off of the roof, the vendor noticed that connection from the wall clip to the beam is not attached in multiple locations. A third-party vendor had to be hired to rectify this issue. The client was the source of risk due to extended time required by the owner's procurement person taking an extended period of time to write the contract. The late issuance of NTP and mechanical and electrical upgrades also took extended time. The unforeseen risks associated with the project include the metal deck deterioration, disposing of unsafe steel roof decking, safety issues due to aged ammonia lines, and weather delays. Vendor A was not a source of any change orders (time and cost deviations) during the project. The proposed schedule by Vendor A is shown in Table 7.

Table 7

Project Schedule

No	Critical Activities / Milestones	Proposed Schedule
1	Turn on project	06/01/09
2	Permitting and Engineering	06/22/09
3	Mobilization	06/25/09
4	Temporary wall construction	07/03/09
5	Existing roof removal operations	07/23/09
6	Polyurethane foam application on roof	07/23/09
7	Butyl rubber coating application on roof	07/28/09
8	Polyurethane coating application on roof	07/29/09
9	Clean and prepare existing wall panels	08/02/09
10	Polyurethane foam application on walls	08/09/09
11	Butyl rubber application on walls	08/15/09
12	Fire barrier application on walls	08/19/09
13	Acrylic coating application on walls	08/23/09
14	Clean up	08/30/09
15	Demobilization	08/31/09

Results

One of the biggest advantages of a sprayed in place foam [SPF] system is its energy savings due to seamless encapsulation of the building. The SPF system is known in the construction industry as a thermal insulation (Kashiwagi & Tisthammer, 2002). It also acts as an air sealant by encapsulating and closing the gaps that allow the movement of air. The coating that is applied over the foam can perform at freezing temperatures (Kashiwagi & Pandey, 1997). The Florida environment also has high humidity, thus moving moisture with the air movement. This combination of air and moisture movement increases the use of energy in the Kansas Marine cold storage facilities. Table 8 shows the difference in temperature and vapor pressure through the proposed six inches of SPF. There are three major analyses: When the outside temperature is 80 degrees F, with outside temperature of 100 degrees F, and without a butalyne moisture barrier. The inside temperature is -10 degrees F.

Table 8

Vapor Drive Analysis

		Exterior Temp 80 degrees F			**Exterior Temp 100 degrees F**			**No butalyne moisture barrier**		
No	TVR*	VPA*	SVP*	Saturation	VPA*	SVP*	Saturation	VPA*	SVP*	Saturation
1	Exterior Air Space	1.030	1.030	0.000	1.03	1.93	-0.90	1.03	1.03	0.00
2	Urethane Coating	0.992	1.030	-0.038	0.99	1.93	-0.94	0.91	1.03	-0.12
3	Butylthane Coating	0.303	1.030	-0.727	0.30	1.93	-1.63	0.91	1.03	-0.12
4	Polyurethane Foam (1 inch)	0.270	0.623	-0.352	0.27	1.10	-0.83	0.81	0.62	0.18
5	Polyurethane Foam (1 inch)	0.237	0.376	-0.139	0.24	0.60	-0.36	0.70	0.38	0.33
6	Polyurethane Foam (1 inch)	0.204	0.212	-0.008	0.20	0.31	-0.11	0.60	0.21	0.39
7	Polyurethane Foam (1 inch)	0.171	0.113	0.058	0.17	0.16	0.01	0.49	0.11	0.38
8	Polyurethane Foam (1 inch)	0.138	0.054	0.084	0.14	0.07	0.07	0.39	0.05	0.33
9	Polyurethane Foam (1 inch)	0.105	0.025	0.080	0.10	0.03	0.08	0.28	0.03	0.26
10	Metal Deck	0.022	0.025	-0.003	0.02	0.03	0.00	0.02	0.03	0.00
11	Inside air film	0.022	0.022	0.000	0.02	0.02	0.00	0.02	0.02	0.00

*VPA – Vapor Pressure Absolute, SVP – Saturation Vapor Pressure, TVR – Thermal and Vapor Resistance

Where the vapor pressure is greater than the saturation pressure, water will condense in the newly installed roofing insulation system. It can be clearly seen that a moisture barrier will be required which is included in the installed urethane coated SPF system. To meet code, the combined urethane [45 mils] /butalyne [mils] system had to be fire tested to meet either the ASTM E-108 or the FM Class 1 flame spread test requirements of a maximum of six feet in 10 minutes.

The proposed granulated urethane/butalyne coated six inches of SPF was a modification from the manufacturer Alpha system and was warranted for 15 years. The modification allowed the

minimization of moisture in the SPF insulation. Although this is a theoretical calculation, the assumptions are simple moisture transfer equations.

In 2014, the author revisited the facility site to verify the roofing waterproofing performance. The roof was in great condition with no observable defects, no ice formations from vapor drive through the roofing system. The author inquired whether the tenant had any energy cost data and upon learning that the information was readily available the energy cost saving analysis was performed. The raw energy usage for the tenant from July 2008 to June 2014 is in Attachment A. The monthly energy cost before and after the roof was insulated is shown in Table 9. The overall standard deviation for the energy cost is $2,177 and the overall standard deviation for the energy usage in kilowatts is 19,607.

Table 9

Monthly Energy Cost

Criteria	Cost
Average Monthly Energy Cost before the roof was insulated	$22,898
Average Monthly Energy Cost after the roof was insulated	$18,930

AVERAGE MONTHLY ENERGY SAVINGS AFTER ROOF INSULATION ($)	**$3,956**
AVERAGE MONTHLY ENERGY SAVINGS AFTER ROOF INSULATION (%)	**17%**

The roof was insulated in late October 2009. Table 9 shows the energy cost and usage from 2008 to the present. Figure 2 shows that the average monthly bill has decreased since the insulation. Figures are missing from two months. Alumbaugh & Humm (1984) also found significant energy savings by the application of foam insulation in their studying of the long-term weathering performance and the energy savings. However, the study on energy savings for sprayed polyurethane foam insulation has not been determined in the industry.

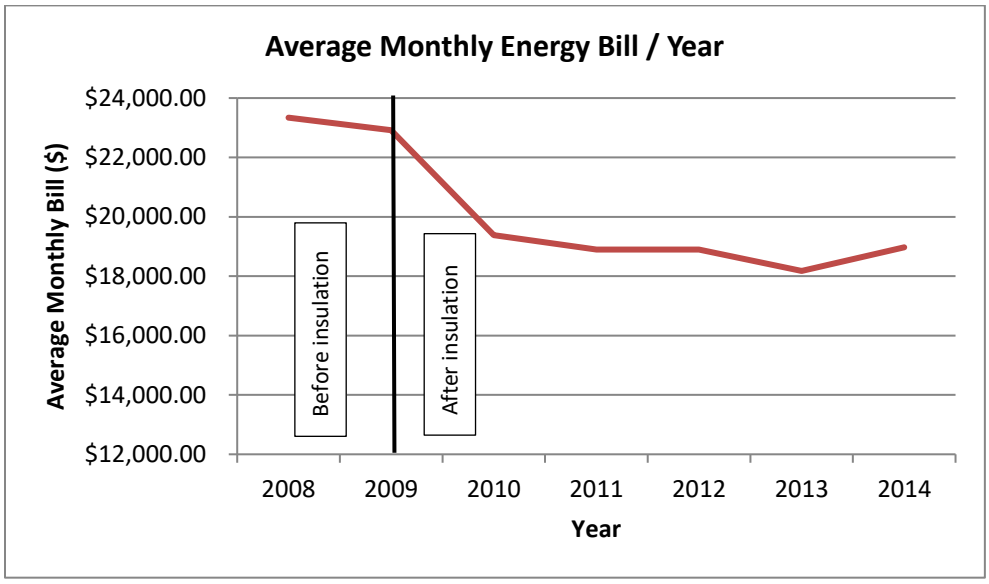

Figure 2: Average Monthly Energy Cost / Year

The researchers analyzed the months for energy costs and usage for deviation and came to the following conclusions:

1. There is no significant deviation in usage or price of energy by month or by year.
2. The average savings in cost per month is 17%.
3. The return on investment is 14 years.
4. The roof is warranted for 15 years. It has been in service for five years and there is no sign of major deterioration.
5. If the roof lasts for the warranted 15 years the energy savings has paid for the roof. The owner has received the roof for free due to the payback in energy savings. The value added is $650K over 15 years.

The FM utilized the BV PIPS system to add tremendous value to the owner of the facility. The roof performed, returned the roof value back in 14 years, and has a potential life of over 20 years (Kashiwagi & Tisthammer 2002)]. The FM utilized the expertise of expert vendors, with no technical knowledge of the facility.

Conclusion

In 2009, the facility manager tested the Best Value (BV) Performance Information Procurement System (PIPS) to deliver a solution to a very troublesome cold storage facility. Five vendors responded to the solicitation. The BV PIPS matrix was heavily weighted on price and interview to ensure that the vendor had expertise to minimize risk and cost and that the solution would be acceptable to the owner who had previously paid for the reroofing and was now being asked to pay an additional $650K to fix the problem.

Based on the study, the following was concluded:

1. The FM did not have confidence in running the traditional design, bid, award process due to the failure of the traditional system to ensure roof performance six years earlier despite utilizing a professional engineer, certified contractor, in possession of a manufacturer's warranty.
2. The FM ran the BV PIPS process without knowing the source of the problem, without any technical experience and without the assistance of a professional technical designer.
3. The BV Vendor A had the lowest price, the most creative and acceptable solution, and used their expertise to identify the source of the ice formation inside of the cold storage units.
4. One of the competitors attempted to use their status of being a large nationwide contractor rather than proving their capability. The contractor was non-competitive and the FM identified that the vendor did not understand the concept of proving their performance and expertise.
5. The BV contractor waterproofed the cold storage facility, fixed structural issues, completely replaced the roofing and wall attachments of the cold storage facility, and installed an encapsulating roofing/waterproofing system.
6. Installed a 15 year warranted urethane coated sprayed polyurethane roof system that saved the tenant $19K/month or 17% of their energy consumption [payoff duration of 14 years].
7. The Cold Storage facility is working well with no return of ice stalagmites in the freezers after five years.

The BV test impressed the owner, the code compliance group, the facility manager and the tenant. The tenant management has been extremely pleased with the performance of the sprayed polyurethane and urethane waterproofing coatings on the wall and roofing system which has minimized the penetration of moisture and ice formation in a temperature differential of up to 130 degrees for over five years. Figure 3 shows the pictures of the wall insulation and the roof insulation after the project completion.

Figure 3: Completed Project

After being introduced to sprayed urethane coated SPF roof system, the city inspector created the county SPF specification. After seeing the results of this project, he proposed that the SPF

encapsulation of a cold storage facility could be successful in any location based on its performance in Fort Lauderdale Florida extreme hot and humid environment.

References

Alumbaugh, R. L., & Humm, E. F. (1984). Experimental Polyurethane Foam Roof Systems. *Journal of Cellular Plastics*, 257-273.

Bailey, D. and Bradford, D. (2005). "Membrane and Flashing Defects in Low-Slope Roofing: Causes and Effects on Performance." *J. Perform. Constr. Facil.*, 19(3), 234–243. doi: 10.1061/(ASCE)0887-3828(2005)19:3(234).

Cahill, D. and Puybaraud, M. (1994). Constructing the team: The latham report. *Construction Reports 1944-98*. Blackwell Science ltd, 145-160.

Cavill, S.and Sohail, M. (2005). "Improving Public Urban Services through Increased Accountability." *J. Prof. Issues Eng. Educ. Pract.*, 131(4), 263–273.

CFMA's. (2006). *Construction Industry Annual Financial Survey*, Moss-Adams, LLP, Eighteenth edition.

Liqiang Chen (2013) Establishing Perfect Evalution Mechanism to Improve Cadres' Performance Ability—Exploration and Practice of Leading Cadres' Duties and Accountability Evaluation. ICTE 2013: pp. 1301-1308.

Coffelt, D., Hendrickson, C., and Healey, S. (2010). "Inspection, Condition Assessment, and Management Decisions for Commercial Roof Systems." *J. Archit. Eng.*, 16(3), 94–99. doi: 10.1061/(ASCE)AE.1943-5568.0000014.

Construction Industry Institute (CII). (1995). Pre-project planning handbook, *Construction Industry Institute,* Austin, TX, Special Publication 39-2.

Davis, B., and Sebastian, R. (2009a). The relationship between contract administration problems and contract type, *Journal of Public Procurement,* 9(2), 262-282.

Egan, J (1998). Rethinking construction: The report of the construction task force to the deputy prime minister, John Prescott, on the scope for improving the quality and efficiency of UK construction, *The Department of Trade and Industry*,1 Victoria Street, London, SW1H 0ET.

Flores, V. and Chase, G. (2005). Project controls from the front end, *Cost Engineering,* April 2005, 47 (4), 22-24

Gibson, G. E., Wang, Y., Cho, C. and Pappas, M. (2006). What is preproject planning, anyway? *Journal of Management in Engineering*, 22 (1).

Hamilton, M.R. & Gibson, G.E. (1996). Benchmarking preproject planning effort, Journal of Management in Engineering, 12(2), 25-33.

Hillson, D. A. (1997).Towards a maturity model, *International Journal of Project & Business Risk Management*, 1(1), 35–46.

Kashiwagi, D., Smithwick, J., Kashiwagi, J., and Sullivan, K. (2010). A Case Study of a Best Value Manufacturer, *Journal for the Advancement of Performance Information and Value,* Performance Based Studies Research Group & CIB W117, 2 (1) pp. 23-32.
Kashiwagi, D. T. and Tisthammer, T. (2002) Information Based Delivery System for Sprayed Polyurethane Foam on Roofing, *Journal of Thermal Envelope & Building Science*, (26), 33-52.

Kashiwagi, Dean. "Performance Information Procurement System (PIPS): A Best Value Delivery Process." *A Revolutionary Approach to Project Management and Risk Minimization*. Tempe: Performance Based Studies Research Group, 2009. 9.1 - 9.128. Print

Kashiwagi, Dean. "Best Value Performance Information Procurement System (PIPS)." *2014 Best Value Standard*. Mesa: Kashiwagi Solution Model (KSM), 2014. 2.1 - 2.8. Print.

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

Kashiwagi, Dean T. (May 1996) Intelligent Procurement of Construction Systems. *Journal of Construction Procurement,* 2, 49 –58.

Sohail, M. and Cavill, S. (2008). ”Accountability to Prevent Corruption in Construction Projects.” *J. Constr. Eng. Manage.*, 134(9), 729–738.

Sullivan, K., Kashiwagi, D., Chong, N. (2010). The influence of an information environment on a construction organization’s culture: A case study. *Advances in Civil Engineering*, 2009, Article 387608, (10).

Sullivan, K. and Michael, J. (2011). ”Performance Measurement Approach to Contracting and Delivering Design Services.” *J. Prof. Issues Eng. Educ. Pract.*, 137(4), 248–257

Wicks, A. M., & Roethlein, C. J. (2009). A Satisfaction-Based Definition of Quality. *The Journal of Business and Economic Studies*, *15*(1), 82-97.

Attachment A – Energy Usage for Kansas Marine

	2008		2009		2010		2011	
Month	**Cost**	**Kwatts (x 10^3)**	**Cost**	**Kwatts (x 10^3)**	**Cost**	**Kwatts (x 10^3)**	**Cost**	**Kwatts (x 10^3)**
1			$25,807	292	$21,281	301	$20,197	283
2			$22,900	261	$21,005	297	$18,316	249
3			$23,319	269	$19,896	280	$19,233	263
4			$23,246	258	$19,979	282	$19,083	258
5			$23,049	252	$19,417	271	$18,239	246
6			$21,673	249	n/a	n/a	$19,512	268
7	$24,058	292	$23,361	274	$17,238	238	$19,357	263
8	$21,966	241	$22,865	251	$19,754	269	$16,661	223
9	$24,015	267	$19,923	211	$20,433	284	$19,173	268
10	$23,460	259	$22,835	262	$18,339	249	$18,261	244
11	$24,089	267	n/a	n/a	$17,778	242	$18,722	254
12	$22,449	248	$23,083	265	$19,282	267	$19,972	273
Totals	**$140,037**	**1,574**	**$275,019**	**3,108**	**$232,641**	**3,234**	**$226,727**	**3,092**

	2012		2013		2014	
Month	**Cost**	**Kwatts (x 10^3)**	**Cost**	**Cost**	**Kwatts (x 10^3)**	**Cost**
1	$19,801	291	$18,894	$19,801	291	$18,894
2	$19,197	279	$15,774	$19,197	279	$15,774
3	$18,576	267	$16,412	$18,576	267	$16,412
4	$19,703	286	$15,893	$19,703	286	$15,893
5	$18,393	264	$18,749	$18,393	264	$18,749
6	$19,250	281	$18,203	$19,250	281	$18,203
7	$18,961	272	$19,381	$18,961	272	$19,381
8	$20,097	293	$18,277	$20,097	293	$18,277
9	$19,404	259	$20,244	$19,404	259	$20,244
10	$16,630	241	$19,315	$16,630	241	$19,315
11	$19,255	266	$19,161	$19,255	266	$19,161
12	$17,438	261	$17,809	$17,438	261	$17,809
Totals	**$226,705**	**3,260**	**$218,113**	**$226,705**	**3,260**	**$218,113**