# Infrared Thermography as a Proactive Tool for Roof Maintenance

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**Abstract**

*The use of infrared thermography for flat and low-slope roof inspections has become increasingly common during the last 20 years. Thermography is typically used for condition assessment and forensic studies, as well as quality assurance of new installations. Experience has shown few facilities willing to incorporate thermography into a regular maintenance program. This paper illustrates a six-year case study illustrating how one facility has used thermography to reduce maintenance costs while extending the life of their roofing system and improving its performance. A financial model illustrating savings is also provided.*

## Introduction

Infrared thermography was first used to detect moisture entrapment within flat and low slope roofing systems in the 1970's. Since that time its usage has steadily increased with millions of square feet now inspected annually worldwide. Widespread usage of thermography led to the publication of Standard Practice C-1153 by ASTM in 1990.

Generally, thermography can be applied to built-up and single-ply roofing systems where either an insulating roof deck or a layer of insulation is located in direct and continuous contact with the underside of the roof membrane. Thermography may be performed from aircraft or ground-based. With the proper equipment, technique, and training, a thermographer can detect and document areas of moisture infiltration ranging from a few square inches to thousands of square feet.

For varied reasons, many facility managers do not perform routine roof maintenance. Often if the roof is not leaking, there is no motivation to perform inspections of any type. Our experience indicates that thermography is generally used only after a roof has entered failure or as a quality assurance tool for new installations and retrofits.

In order to assess the effectiveness of thermography as a maintenance tool, annual infrared inspection reports covering a five-year period for a large warehouse were studied. Results were then compared with maintenance costs and building performance. This paper documents and discusses the results of that study.

## Case History

The Pennsylvania Liquor Control Board is a state agency, which operates a 360,000-square-foot warehouse and distribution center in Philadelphia, Pennsylvania. The roof comprises a corrugated metal deck covered with wood fiber insulation, and a coal-tar-built-up membrane covered with slag. The roof is divided into eight discrete areas on two elevations.

In 1992, the roof began to experience leaks in several areas. Faced with a 22 year old roof entering failure, PLCB management began to investigate the possibility of replacing or retrofitting the entire roof. Cost estimates for replacement ranged from 2.5 to over 3 million dollars.

In order to help assess the condition of the existing system, Jersey Infrared Consultants were engaged to perform an infrared inspection of the entire roof in September 1992.

## Findings

On September 14, 1992, an infrared inspection was performed using an Inframetrics 522 infrared imaging system. All work was performed in accordance with ASTM Standard Practice C-1153. All thermal data were verified with core samples and correlated moisture-meter readings. All wet areas were outlined on the roof surface with spray paint.

Our infrared inspection found seven separate wet areas comprising a total of 1,208 square feet of subsurface moisture. With less than one percent of the roofing system requiring replacement, a roofing contractor was hired by the PLCB to remove the moisture-damaged areas and to make other necessary repairs. The total cost of the repairs and the infrared inspection for 1992 totaled $20,705.

In order to verify the 1992 roof repairs and to re-assess the condition of the entire roof, another infrared inspection was performed in December 1993. Our 1993 inspection found seven new wet areas comprising a total of 1,399 square feet of subsurface moisture. Once again, less than one percent of the roofing system required replacement. A roofing contractor was again hired by the PLCB to remove the moisture-damaged areas and to make other necessary repairs. The total cost of repairs and the infrared inspection for 1993 totaled $18,217.

Pleased with improved roof system performance and repair costs far less than replacement, the PLCB opted to perform infrared inspections and repairs annually beginning in 1994. The results of these inspections are listed in Table 1.

**Table 1**

| Year | Number of Wet Areas | Area of Damage (sf) | Percent Damage | Annual Cost |
|---|---|---|---|---|
| 1992 | 7 | 1208 | <1 | $20,705 |
| 1993 | 7 | 1399 | <1 | 18,217 |
| 1994 | 3 | 83 | <1 | 5,865 |
| 1995 | 1 | 30 | <1 | 4,020 |
| 1996 | 1 | 144 | <1 | 4,270 |
| 1997 | 5 | 172 | <1 | 6,224 |
| | | | **Total** | **$59,301** |

The total cost for infrared inspections and repairs for the period 1992 through 1997 totaled $59,301.

Of particular note is the annual decrease in the total area of damage after 1993. For years 1994 and 1995, the total damage is confined to less than 100 square feet annually and less than 200 square feet in both 1996 and 1997.

Additionally, the overall sizes of the largest wet areas ranged from 276 to 400 square feet in 1992 and 1993 while the largest wet areas have ranged from 30 to 144 square feet since 1994. Not surprising is the reduction in annual maintenance costs. With less damage to repair, annual costs are reduced.

## Discussion

Since the annual infrared inspection and preventive maintenance program began, no areas of moisture damage have been detected in the same location from year to year. This would suggest that effective repair efforts were accurately directed to the problem areas.

The number of problems detected annually has decreased and the overall sizes of the wet areas detected have also decreased since 1992. This would suggest that wet areas detected after 1993 were being caught in their formative stages. The proactive approach of combining infrared inspections with proper repairs has helped to reduce annual maintenance costs.

Building management also reports an overall increase in the performance of the building. With fewer leaks annually and less damage in the roofing system, there is a greater amount of usable floor space available within the building. In many instances, the infrared inspections have detected moisture damage within the roof before corresponding leaks were experienced within the building.

When thermography was utilized in 1992, a replacement option for the roof was being considered. The results from the infrared inspection, combined with effective repairs, have allowed management to retain the original roof and avoid the expense associated with replacement or retrofit. This savings allows the money to be used for other purposes or invested.

For a privately owned facility of this size, budgeting a capital outlay of 3 million dollars at an interest rate of 10%, interest would amount to $300,000 for the first year alone. Using these figures, the interest for the first year is more than 5 times the entire proactive costs for a 6-year period!

When calculated for a five-year period, interest costs for replacement would total $900,000. Subtracting the total proactive costs of $59,599, we realize a savings of over $840,000.

It should be noted that neither energy savings nor the avoided cost of lost product were considered for this facility. Had they been considered, the actual savings would have been greater.

## Conclusion

By utilizing thermography as a proactive maintenance tool, it is possible to increase the performance of the roof while extending its useful service life as well as reduce overall maintenance costs. The effectiveness of such a program will depend upon the quality of the data obtained from the infrared inspection as well as the quality of the repairs.

While this paper studied only one building, the implications for similar success on other buildings make a strong case for this type of proactive maintenance program. Since the overall success will depend upon the initial condition of the roof, infrared inspections should be implemented before the roof begins to leak. Where possible, the roof should be inspected soon after installation and annually thereafter.

## References

ASTM C- 1153 Standard Practice for the Location of Wet Insulation in Roofing Systems Using Infrared Imaging.

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