Infrared Thermographic
Building Envelope Analysis

PERFORMED FOR:	**Viking Construction** **1387 Seaview Ave.** **Bridgeport, CT 06607**
LOCATION:	**Roxbury Elementary** **Stamford, CT**
CONDUCTED ON:	**April 17, 2019**
REQUESTED BY:	**Jo Ann Michaels**
PERFORMED BY:	**Jeff Demeter, Certified Thermographer**

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May 7, 2019

Jo Ann Michaels
Viking Construction
1387 Seaview Ave.
Bridgeport, CT 06607

Dear Jo Ann,

This report summarizes the findings of the Infrared Building Envelope Analysis performed at the Roxbury Elementary School, Stamford, CT, performed on April 17, 2019.

INFRARED THERMOGRAPHY

All objects emit heat (i.e. infrared radiation). This radiation is constantly being absorbed and re-emitted by ourselves and everything around us. "Infrared scanning" and "thermography" are the terms used to describe the process of making this thermal radiation visible and capable of interpretation.

Infrared Building Envelope Analysis locates and documents building heat loss and moisture damage problems. Infrared Thermography is the only non-destructive and complete system for locating and documenting causes of frozen pipes, ice dams, damaged or missing insulation, moisture damaged building materials, warm air exfiltration, cold air infiltration, and high heating costs. Infrared Building Envelope Surveys provide valuable information for trouble-shooting building envelope problems, evaluating energy retrofits, and developing practical and cost-effective energy solutions.

Our Infrared cameras can also be used in a variety of other Non-Destructive testing applications:

- Infrared Electrical/Mechanical Inspections pinpoint developing problems in power delivery systems. The infrared scanner can "see" hot spots where there are going to be failures before they happen. This Predictive Maintenance approach provides for time to repair these problem areas before they cause equipment damage, unscheduled outages, and expensive down time. Problem areas are pinpointed, prioritized and fully documented.

- Infrared Steam System Inspections pinpoint failing steam traps, malfunctioning heat exchangers and boiler problems. These surveys can save thousands of dollars by reducing energy usage.

- Infrared Roof Moisture Surveys pinpoint moisture damage within roofing systems to help you target problem areas and wet insulation for more cost-effective repairs or roof replacement. Our roof moisture surveys provide independent, objective information about the real condition of your roof system so you can make sound decisions and sift through conflicting opinions and advice.

INSTRUMENTATION

Infra-red Analyzers uses top-quality instruments when performing your Building Envelope Analysis. The portable, high-resolution FLIR T420 is one of the most sensitive and sophisticated scanners available. The T420 can resolve temperature differences < 0.05 degree Celsius, measure temperatures from -20 to 650°C, and offers thermal/visual/fused thermal image/Pi-P/MSX imaging options. In combination with the powerful FLIR Tools+ software, the T420 system enables highly detailed image/data processing in the Windows® environment.

The camera unit receives infrared radiation from the object being surveyed and converts it to an electrical signal that is instantaneously displayed on the color viewfinder. This high-resolution thermal image is then interpreted by Infra-red Analyzers' Certified Thermographers.

THERMOGRAM INTERPRETATION AND DOCUMENTATION

Hard copy documentation of the survey findings is provided through Thermograms and Control Photos. In the Thermograms, temperatures are indicated in various colors. The following is a chart illustrating the hierarchy of colors that the FLIR T420 uses to represent the relative temperature differences of the surface temperatures:

When viewing thermograms that were recorded on the warm side of the thermal envelope (inside the building), the colors that represent cooler temperatures (black, purple & blue) generally represent heat loss problems. When viewing images recorded on the cold side of the thermal envelope (outside of building) surface areas represented by warmer colors (white, red, yellow & green) represent areas of heat loss from the building. Typically heat loss occurs due to reduced insulation value in a wall system and/or air leakage into or out of the heated space.

When scanning from the outside in the cooler months, thermal imagers are limited in their radiometric (temperature measurement) functions. In order to maintain consistent qualitative information, occasionally the scale in the thermogram will be converted to a luminance reading rather than a temperature calibrated output. This allows the thermal imager to provide accurate high-quality thermal imagery at low temperatures. The luminance scale may also be employed at lower Delta T's (inside vs outside) to improve consistency in the thermographic imagery.

The next section of the report contains the 8 sets of thermograms and control photos that were generated during the inspection.

Key to Thermogram Explanations

Thermogram #: 1,2,3,4 etc

Facility: Building being surveyed.

Location of Target: Floor and/or room being surveyed.

Target Shown: Building elevation and/or specific area being surveyed.

Position/Location Taken From: Thermographer's location when recording the thermogram.

Camera Direction: Direction the camera was facing when the thermogram was taken.

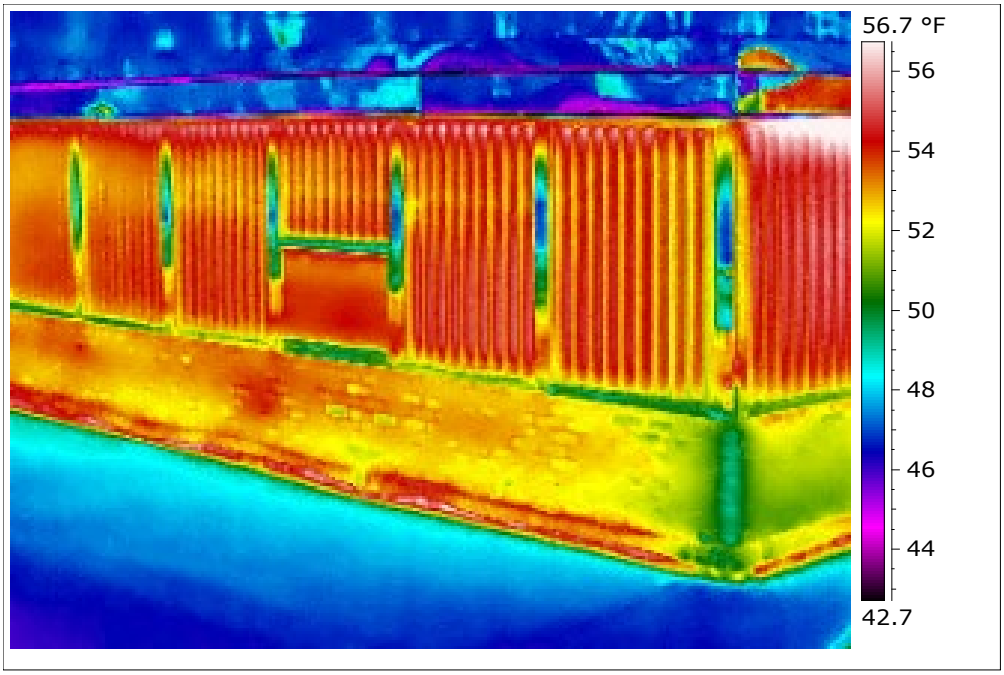
Building Component: The actual component being documented: wall, window, door etc.

Problem Category: Typically the types of problems documented will be Conduction Losses, Air Leakage Losses (infiltration/exfiltration), and Moisture Damage.

Recommendation: These are general guidelines for practical and cost-effective ways to correct the problem.

Control Photo: Visible Light Image

Thermogram: Infrared Image



Thermogram # **1**

Thermogram #: 1

Facility/Building: Roxbury Elementary

Location of Target: South Elevation

Target Shown: Gym rising wall – east portion

Position/Location of Thermographer: Outside – Sec. 3 Roof

Camera Direction: Northwest

Building Component: Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: **WALL -** There are significant conduction losses through the sidewall in this area. Some of the warmer areas may be caused in part by moisture in the wall materials. If possible, the construction of this wall should be physically investigated to determine if moisture is present or if the wall is insulated, and if the insulation has been properly installed. Although there are significant heat losses here, retrofitting sidewalls can involve substantial expense. There may not be a practical, cost-effective way to reduce these conduction losses. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.

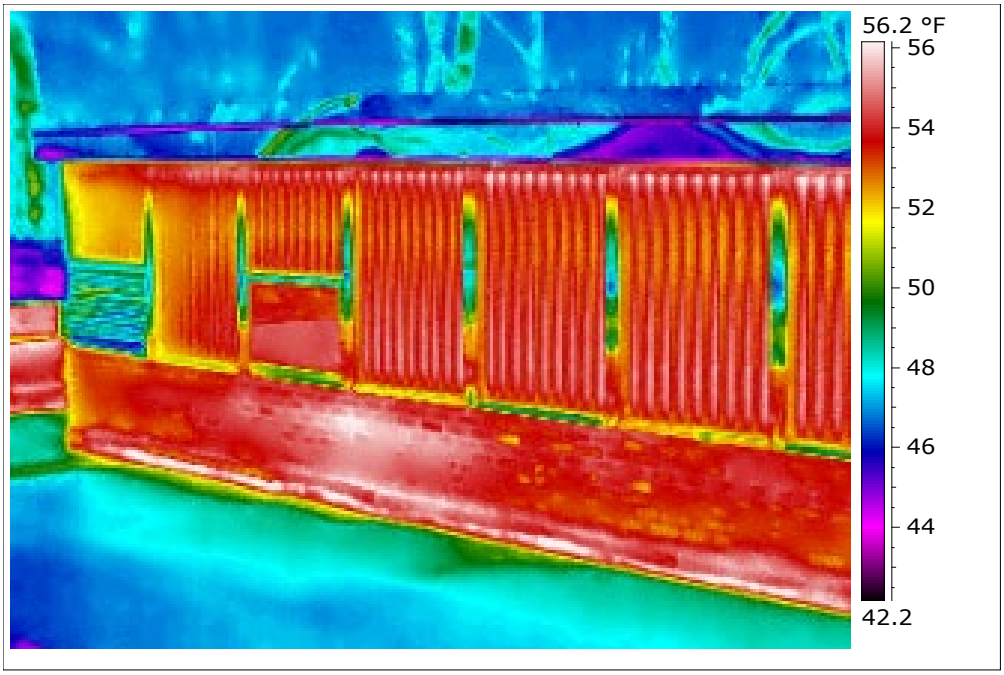
WALL - Overall, the majority of the sidewall area exhibited typical performance with occasional areas of conduction loss through the brick. The overall infrared patterns were quite consistent with only occasional thermal anomalies. However, there were periods of sunshine during the day preceding the testing and this can have an effect on the imagery. Therefore, in this Thermogram, the temperature increases noted on brick wall could be at least partially caused by residual solar gain. When construction techniques are relatively uniform throughout a structure, and in situations where solar loading may be a factor, the west, south and east exposures may exhibit increases in temperature related to solar gain, while north elevations will typically be less affected.

Thermogram #1 (continued)

WALL/ROOF - It appears that there may be both air leakage and conduction at the top of the wall in this area. In order to devise a practical and cost-effective retrofit, a thorough physical examination of the joints and penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc) should be employed to reduce or eliminate any gaps allowing warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and lowered heating costs. Any areas of poorly installed or insufficient insulation could also be addressed at this time.

Control Photo: Visible Light Image

Thermogram: Infrared Image



Thermogram # **2**

Thermogram #: 2

Facility/Building: Roxbury Elementary

Location of Target: South Elevation

Target Shown: Gym rising wall – west portion

Position/Location of Thermographer: Outside – Sec. 3 Roof

Camera Direction: Northwest

Building Component: Wall

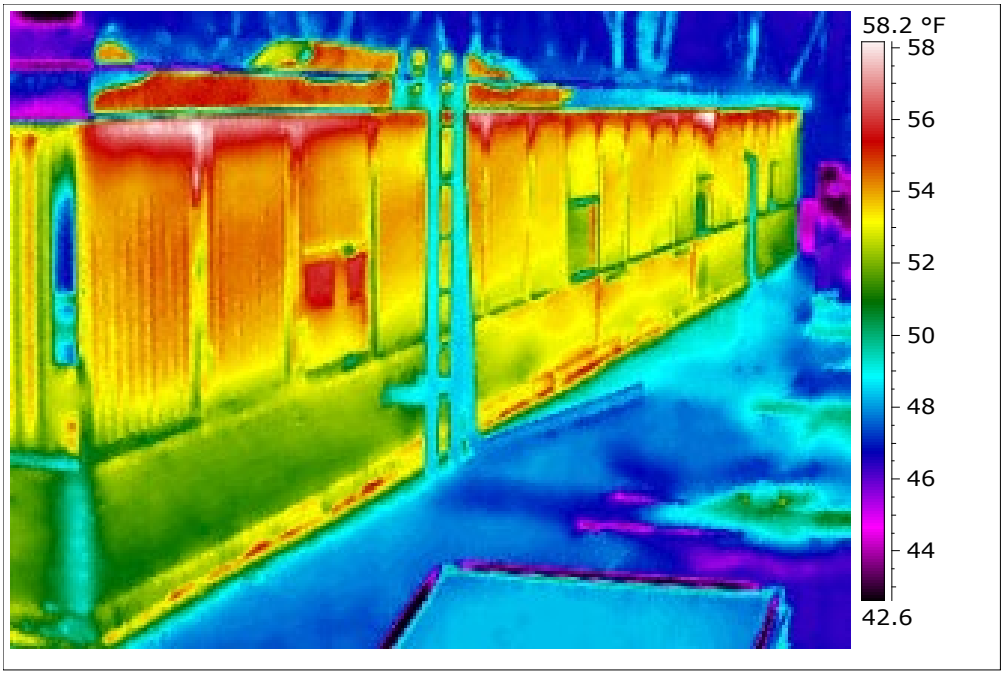
Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: **WALL -** There are significant conduction losses through the sidewall in this area. Some of the warmer areas may be caused in part by moisture in the wall materials. If possible, the construction of this wall should be physically investigated to determine if moisture is present or if the wall is insulated, and if the insulation has been properly installed. Although there are significant heat losses here, retrofitting sidewalls can involve substantial expense. There may not be a practical, cost-effective way to reduce these conduction losses. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.

WALL - Overall, the majority of the sidewall area exhibited typical performance with occasional areas of conduction loss through the brick. The overall infrared patterns were quite consistent with only occasional thermal anomalies. However, there were periods of sunshine during the day preceding the testing and this can have an effect on the imagery. Therefore, in this Thermogram, the temperature increases noted on brick wall could be at least partially caused by residual solar gain. When construction techniques are relatively uniform throughout a structure, and in situations where solar loading may be a factor, the west, south and east exposures may exhibit increases in temperature related to solar gain, while north elevations will typically be less affected.

Control Photo: Visible Light Image

Thermogram: Infrared Image



Thermogram # **3**

Thermogram #: 3

Facility/Building: Roxbury Elementary

Location of Target: East Elevation

Target Shown: Gym rising wall – wall/windows/corrugated

Position/Location of Thermographer: Outside – Sec. 3 Roof

Camera Direction: Northwest

Building Component: Wall

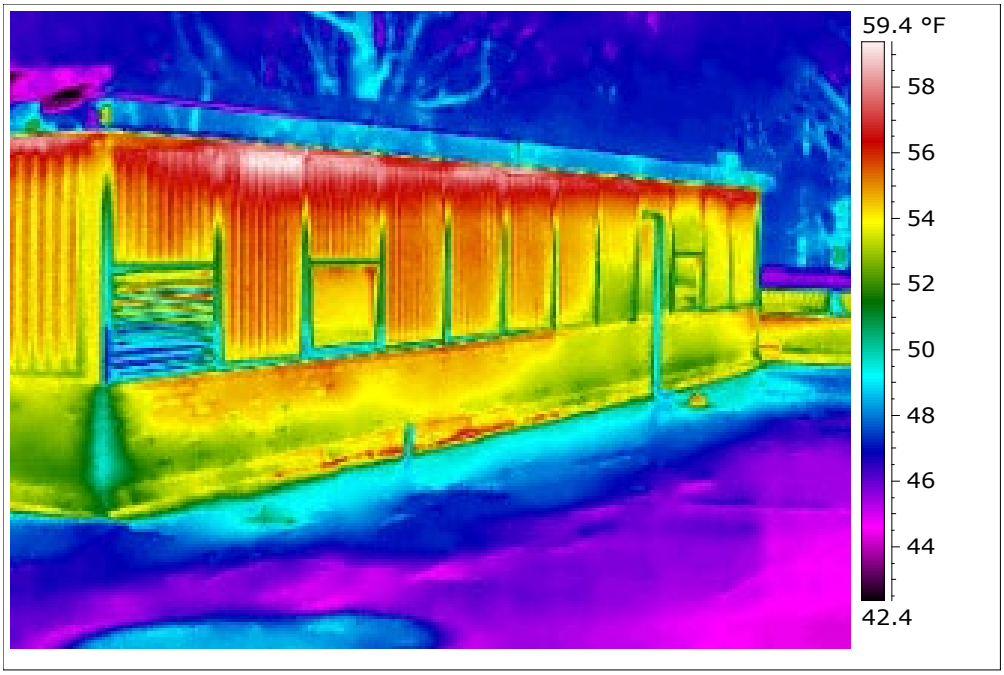
Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: WALL - There are significant conduction losses through the sidewall in this area. Some of the warmer areas may be caused in part by moisture in the wall materials. If possible, the construction of this wall should be physically investigated to determine if moisture is present or if the wall is insulated, and if the insulation has been properly installed. Although there are significant heat losses here, retrofitting sidewalls can involve substantial expense. There may not be a practical, cost-effective way to reduce these conduction losses. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.

WALL/ROOF - It appears that there may be both air leakage and conduction loss in this area. In order to devise a practical and cost-effective retrofit, a thorough physical examination of the joints and penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc) should be employed to reduce or eliminate any gaps allowing warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and lowered heating costs. Any areas of poorly installed or insufficient insulation could also be addressed at this time.

Control Photo: Visible Light Image

Thermogram: Infrared Image



Thermogram # **4**

Thermogram #: 4

Facility/Building: Roxbury Elementary

Location of Target: North Elevation

Target Shown: Gym rising wall – wall/windows/corrugated

Position/Location of Thermographer: Outside – Sec. 1 Roof

Camera Direction: South

Building Component: Wall

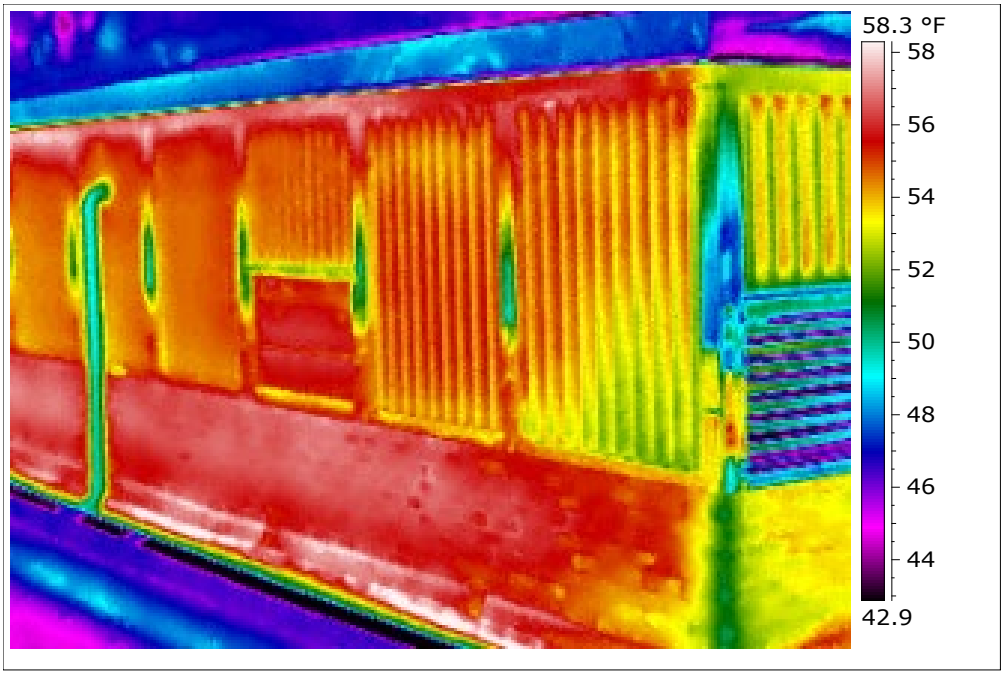
Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: WALL - There are significant conduction losses through the sidewall in this area. Some of the warmer areas may be caused in part by moisture in the wall materials. If possible, the construction of this wall should be physically investigated to determine if moisture is present or if the wall is insulated, and if the insulation has been properly installed. Although there are significant heat losses here, retrofitting sidewalls can involve substantial expense. There may not be a practical, cost-effective way to reduce these conduction losses. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.

WALL/ROOF - It appears that there may be both air leakage and conduction loss in this area. In order to devise a practical and cost-effective retrofit, a thorough physical examination of the joints and penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc) should be employed to reduce or eliminate any gaps allowing warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and lowered heating costs. Any areas of poorly installed or insufficient insulation could also be addressed at this time.

Control Photo: Visible Light Image

Thermogram: Infrared Image



Thermogram # **5**

Thermogram #: 5

Facility/Building: Roxbury Elementary

Location of Target: West Elevation

Target Shown: Gym rising wall – southern portion windows/wall/corrugated

Position/Location of Thermographer: Outside – Sec. 3 Roof

Camera Direction: Northwest

Building Component: Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: WALL - There are significant conduction losses through the sidewall in this area. Some of the warmer areas may be caused in part by moisture in the wall materials. If possible, the construction of this wall should be physically investigated to determine if moisture is present or if the wall is insulated, and if the insulation has been properly installed. Although there are significant heat losses here, retrofitting sidewalls can involve substantial expense. There may not be a practical, cost-effective way to reduce these conduction losses. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.

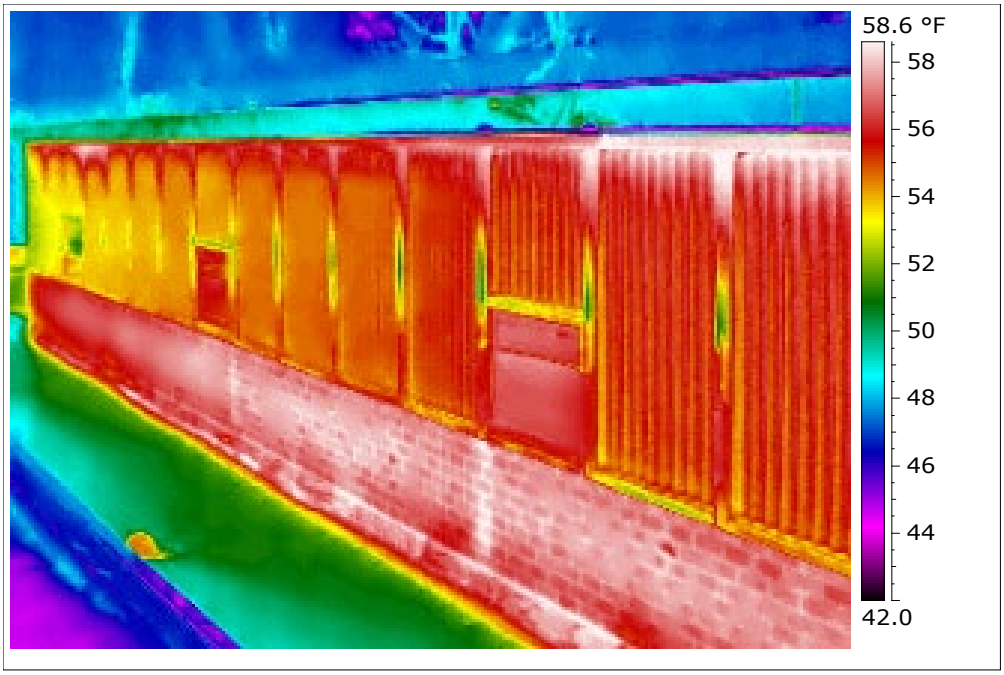
WALL - Overall, the majority of the sidewall area exhibited typical performance with occasional areas of conduction loss through the brick. The overall infrared patterns were quite consistent with only occasional thermal anomalies. However, there were periods of sunshine during the day preceding the testing and this can have an effect on the imagery. Therefore, in this Thermogram, the temperature increases noted on brick wall could be at least partially caused by residual solar gain. When construction techniques are relatively uniform throughout a structure, and in situations where solar loading may be a factor, the west, south and east exposures may exhibit increases in temperature related to solar gain, while north elevations will typically be less affected.

Thermogram #5 (continued)

WALL/ROOF - It appears that there may be both air leakage and conduction at the top of the wall in this area. In order to devise a practical and cost-effective retrofit, a thorough physical examination of the joints and penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc) should be employed to reduce or eliminate any gaps allowing warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and lowered heating costs. Any areas of poorly installed or insufficient insulation could also be addressed at this time.

Control Photo: Visible Light Image

Thermogram: Infrared Image



Thermogram # **6**

Thermogram #: 6

Facility/Building: Roxbury Elementary

Location of Target: West Elevation

Target Shown: Gym rising wall – north portion, windows/brick/corrugated

Position/Location of Thermographer: Outside – Sec. 2 Roof

Camera Direction: North

Building Component: Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: WALL - There are significant conduction losses through the sidewall in this area. Some of the warmer areas may be caused in part by moisture in the wall materials. If possible, the construction of this wall should be physically investigated to determine if moisture is present or if the wall is insulated, and if the insulation has been properly installed. Although there are significant heat losses here, retrofitting sidewalls can involve substantial expense. There may not be a practical, cost-effective way to reduce these conduction losses. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.

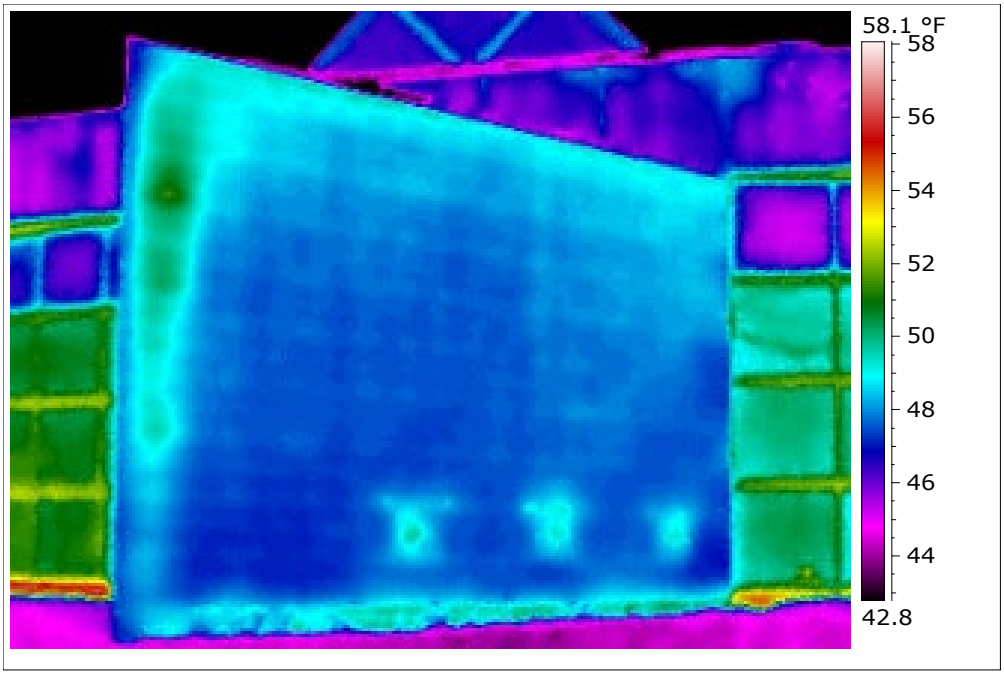
WALL - Overall, the majority of the sidewall area exhibited typical performance with occasional areas of conduction loss through the brick. The overall infrared patterns were quite consistent with only occasional thermal anomalies. However, there were periods of sunshine during the day preceding the testing and this can have an effect on the imagery. Therefore, in this Thermogram, the temperature increases noted on brick wall could be at least partially caused by residual solar gain. When construction techniques are relatively uniform throughout a structure, and in situations where solar loading may be a factor, the west, south and east exposures may exhibit increases in temperature related to solar gain, while north elevations will typically be less affected.

Thermogram #6 (continued)

WALL/ROOF - It appears that there may be both air leakage and conduction at the top of the wall in this area. In order to devise a practical and cost-effective retrofit, a thorough physical examination of the joints and penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc) should be employed to reduce or eliminate any gaps allowing warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and lowered heating costs. Any areas of poorly installed or insufficient insulation could also be addressed at this time.

Control Photo: Visible Light Image

Thermogram: Infrared Image



Thermogram # **7**

Thermogram #: 7

Facility/Building: Roxbury Elementary

Location of Target: East Elevation

Target Shown: Sec. 16 – entire wall

Position/Location of Thermographer: Outside – Lawn

Camera Direction: Northwest

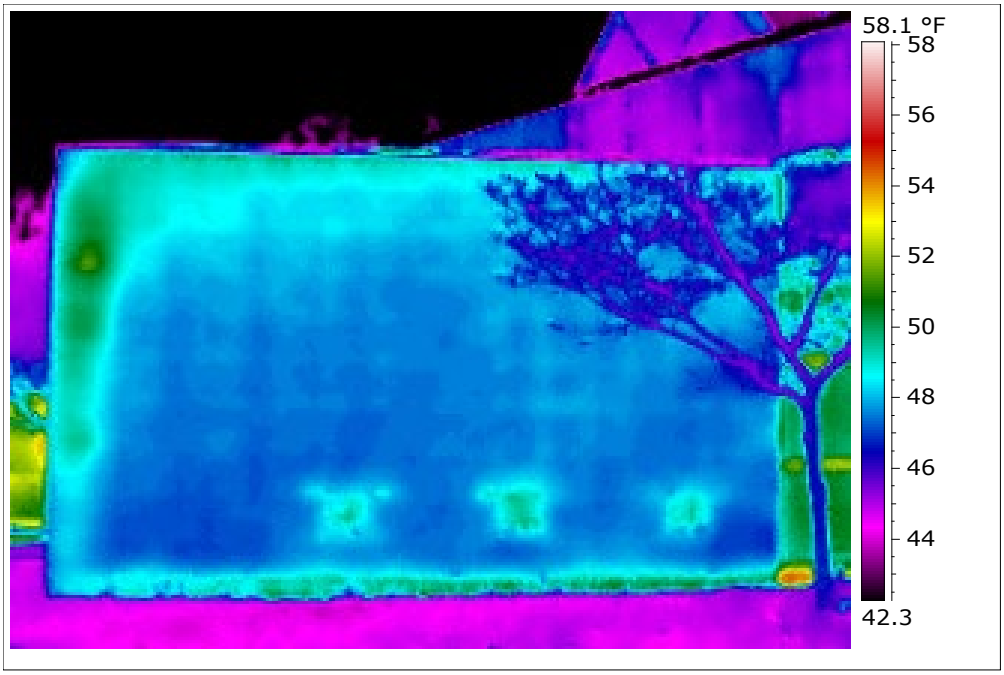
Building Component: Wall

Problem Category: Conduction Loss

Recommendation: The top corner (south end) of this wall displays an unusual anomaly that may indicate a moisture buildup in this area. Invasive testing in this area may be required to determine the presence or absence of moisture. It is also possible that air leakage (exfiltration) is occurring through the joints of the cladding in this area.

Control Photo: Visible Light Image

Thermogram: Infrared Image



Thermogram # **8**

Thermogram #: 8

Facility/Building: Roxbury Elementary

Location of Target: East Elevation

Target Shown: Sec. 16 – entire wall

Position/Location of Thermographer: Outside – Lawn

Camera Direction: West

Building Component: Wall

Problem Category: Conduction Loss

Recommendation: The top corner (south end) of this wall displays an unusual anomaly that may indicate a moisture buildup in this area. Invasive testing in this area may be required to determine the presence or absence of moisture. It is also possible that air leakage (exfiltration) is occurring through the joints of the cladding in this area.

SUMMARY

The testing at the Roxbury Elementary uncovered some significant areas of heat loss, and they are documented in this report. Typically, when addressing heat loss issues the air leakage problems are assigned higher priorities. While most buildings have both conduction and air leakage losses, addressing the air leakage problems is usually the simplest and most cost-effective way to improve the thermal performance of the building envelope. Air movement through the building envelope can often be reduced or eliminated using simple, inexpensive and easily applied materials. While conduction losses through the solid materials in the structure may also be significant, it is typically more expensive and disruptive to reduce the conduction losses through walls, windows and doors. It may be prudent to perform a complete cost/benefit analysis before undertaking retrofits designed to reduce any conduction losses.

The issues documented during the testing are listed below in approximate priority order, i.e the recommendations at the beginning of the summary appear to constitute the most practical and cost-effective actions, while those at the end will probably require greater expense and result in a longer return on investment (ROI).

WALL - In Thermograms 7 & 8, the top corner (south end) of this wall displays an unusual anomaly that may indicate a moisture buildup in this area. Invasive testing in this area may be required to determine the presence or absence of moisture. It is also possible that air leakage (exfiltration) is occurring through the joints of the cladding in this area.

WALL/ROOF - It appears that there may be both air leakage and conduction at the top of the wall in Thermograms #1, 3, 4, 5 & 6. In order to devise a practical and cost-effective retrofit, a thorough physical examination of the joints and penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc) should be employed to reduce or eliminate any gaps allowing warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and

lowered heating costs. Any areas of poorly installed or insufficient insulation could also be addressed at this time.

WALL – In Thermograms #1 – 6, there are significant conduction losses through the sidewall in these areas. Some of the warmer areas may be caused in part by moisture in the wall materials. If possible, the construction of this wall should be physically investigated to determine if moisture is present or if the wall is insulated, and if the insulation has been properly installed. Although there are significant heat losses here, retrofitting sidewalls can involve substantial expense. There may not be a practical, cost-effective way to reduce these conduction losses. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.

WALL - Overall, the majority of the sidewall area exhibited in Thermograms #1, 2, 5 & 6 show typical performance with occasional areas of conduction loss through the brick. The overall infrared patterns were quite consistent with only occasional thermal anomalies. However, there were periods of sunshine during the day preceding the testing and this can have an effect on the imagery. Therefore, in these Thermograms, the temperature increases noted on brick wall could be at least partially caused by residual solar gain. When construction techniques are relatively uniform throughout a structure, and in situations where solar loading may be a factor, the west, south and east exposures may exhibit increases in temperature related to solar gain, while north elevations will typically be less affected.

Jo Ann, thank you for using our Infrared Services. Please call me if you have any questions regarding this report, or if I can help in any way.

Sincerely,

J.P. Phillips
Director of Operations