INFRARED ROOF MOISTURE SURVEY

[redacted]

[redacted]

[redacted]

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I. ABSTRACT

An infrared moisture analysis and an electric impedance meter test was conducted on the roof at [redacted] to detect and define any areas of moisture damaged roof insulation and moisture on the concrete decking below dry insulation. The surveys took place on [redacted]. The tests are non-destructive test methods that utilize both thermal imaging and a Tramex Moisture Meter to locate substrate moisture entrapment within the roof composite.

The basic tool of the ***Spectrum Infrared Roof Survey*** is the **Fluke TiR32** Thermal Imaging System. The camera operates using a Focal Plane Array (Uncooled Microbolometer). Electromagnetic thermal energy radiating from an object is converted into electronic video signals and displayed on a field monitor. The camera senses the intensity of thermal radiation from a surface and displays a monochrome image whose density corresponds to the radiation intensity. The radiant energy levels are interpreted as surface temperatures.

Water enters the roof system by means of splits, holes or faulty flashing, causing the roofing components (i.e. insulation, felts, decking) to become wet. The wetter areas store more heat from daytime solar loading and remain warmer at night. Reduced thermal value of water damaged insulation and/or decking materials also allows for heat transfer of interior energy through the wet components during the colder months. It is this thermal radiation of water present in the roof that the infrared camera records. The hot spots are visible on the surface of the roof when viewed through the infrared camera. Buildings with concrete decks rely mainly on solar loading to heat the roof system, therefore scanning concrete decked roof systems during the winter and roof sections that remain in shadow during the day (below units, overhangs, under gratings, etc.) provide negligible thermal profiles.

Moisture entering the roof system at penetrations and base flashings that does not affect the insulation will not be detected by the infrared camera, because the moisture can flow directly into the building interior, leaving the insulation unaffected. This can typically occur at pipe penetrations, pitch boxes, ventilators, mechanical units, skylights and masonry walls.

The rooftop is scanned during the evening- at sundown in the winter, and one (1) to two (2) hours after sundown in the summer (these conditions may vary due to the type of roof membrane). Scanning at night allows for sufficient cooling of the roof surface and eliminates solar reflection resulting in a more accurate scan.[1]

Areas affected, if any, are marked on the roof surface with spray paint. The markings should not be removed prior to repairs. The thermal anomalies painted on the roof represent findings identified during the infrared survey. Repairs to the roof system are recommended to be performed as soon as practical. Please note that the findings can only be accurate and representative for the time of the moisture survey. Additional moisture intrusion into the roofing components upon completion of the survey will typically tend to enlarge the areas of substrate moisture identified.

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[1] Infrared scan procedures were conducted in accordance with ASTM Standard C1153 - 97(2003)e1- "Standard Practice for the Location of Wet Insulation in Roofing Systems using Thermal Imaging".

Additional infrared survey(s) may be required to clearly identify areas of subsurface moisture in cases where the occurrence of the scan and the actual repairs to the roof are time delayed.

Moisture present on or within the decking, located below dry insulation may not always be detected by the infrared camera. Dry, unaffected insulation acts as a thermal barrier between the surface of the roof and the substrate moisture, preventing the transmission of moisture related thermal energy.

Moisture measurements of roofing components as well as verification of suspected substrate moisture/non-moisture can be made using one or more of the following secondary test procedures:

1. Core samples
2. "Delmhorst Model BD-7" moisture meter, with a Type 21E electrode, and equipped with two 3-1/4 inch long pins. The moisture meter probe is inserted into the roof insulation. The measurement is the result of an electrical current and is given in percentage of moisture encountered.
3. The Tramex **RWS** Roof Scanner is a multi-mode non-invasive impedance scanner designed for the instant, precise and non-destructive evaluation of moisture conditions and leak tracing in roofing per ASTM D7954.
4. Visual identification of substrate moisture through cuts or other openings in the roof membrane.

These types of measurements represent only localized conditions and should not be interpreted as representative for the entire roof.

Cores and test probes, if taken, are repaired using appropriate repair methods, including EPDM, TPO, PVC, spray foam, modified bitumen and built up roofs.

II. PROFILE

Building: [redacted]

Date of Scan: [redacted]

Roof Area Scanned in Square Feet: 6,700 sf

Number of Moisture Affected Areas on Roof: Five (5)

Amount of Wet Insulation Detected: 277 sf

Area of Moisture Detected on the Roof Deck Below Dry Insulation (Tramex Readings): 1,401 sf

Percentage of Roof Moisture Affected: 24% of the roof area

Roof Composition:

- Concrete Decking
- 4" Polyisocyanurate Insulation
- Soprema Roof Membrane
- Kemper Liquid Applied Waterproof Membrane

Conditions: Skies- Clear
Exterior Air Temperatures- 76 degrees F.
Winds- 2-6 mph
Start Time of Survey- 10: 00 p.m.

III. EVALUATION

The infrared and Tramex Impedance roof moisture scans were conducted to locate and defining areas of moisture damaged insulation and possible moisture on the concrete decking. The survey commenced at approximately 10:00 p.m. By the time the scan commenced, the surface temperatures were sufficiently cooled to allow necessary temperature differentials. IR scanning during the evening is necessary for certain temperature differentials to take place, allowing the thermal anomalies to appear. Ambient surface temperatures of dry roofing must be lower than the surface temperatures of moisture affected areas.

The infrared camera views the entire roof area. Large portions of the roof can be scanned at once, and problem areas, if any, are easily isolated and outlined with permanent marking paint. Note: The paint markings will fade with time, therefore if repairs are delayed, please re-mark the existing anomaly outlines after 4 months.

System calibration of the ***Fluke TiR32*** camera is automatic, occurring every 2 minutes. Also utilized for calibration were the thermal imagery identified on the roof as typical for wet and/or damp insulation patterns. Historical readings of similar type roofing component moisture patterns were calibrated with the thermal imagery viewed on the roof, providing accurate thermal definition and interpretation.

General atmospheric conditions were favorable during the survey. Daytime solar gain is retained within the heavier mass of wet insulation. Internal energy loss occurs through damaged insulation in greater amounts than through dry insulation during the winter months.

INFRARED SCAN

Three (3) thermal anomalies indicating wet and moisture damaged insulation were found via the infrared survey, totaling 277 square feet.

- The wet insulation appeared as thermal anomalies typical for water damaged isocyanurate insulation.
- Cause of water entry appears to be from cuts and punctures located at or near the anomaly locations. These cuts an punctures have either membrane repair patches or caulk repairs, seen at the time of the sur vey. The caulk repairs should be replaced with permanent membrane repair patches.
- All anomalies have been outlined with paint on the roof surface.

No other wet insulation anomalies were detected at the time of the scan.

TRAMEX MOISTURE METER TESTING

Four (4) are larger areas of subsurface moisture entrapment were detected using the Tramex

Moisture Meter. This impedance meter detected moisture suspected to be located on the concrete deck, below the insulation. These areas are marked on the roof with a dotted line. The areas, labeled A through D measure approximately 1,401 square feet.

- Damage to the roof membrane during construction had allowed water to enter the roof, however, since the water entry points were quickly repaired, the insulation did not get wet. The moisture settled onto the concrete decking below the insulation boards. Only after repeated cyclical freezing (during the winter months), will the isocyanurate begin to break down from the entrapped moisture.
- The amount of this moisture on the concrete deck is not determined.
- Cuts and punctures repaired with caulking were seen at Areas C and D.

IV. ANOMALY SUMMARY TABLE

Infrared Scan

ANOMALY	DIMENSIONS	SQ. FT.
1	4x4	16
2	6x6	36
3	15x15	225

TOTAL AREA WET INSULATION: 277 SQUARE FEET

Tramex Survey

AREA	IMENSIONS	SQ. FT.
A	8x8	64
B	13x5+47x20	1005
C	9x12	108
D	12x7+20x7	224

TOTAL AREA MOISTURE ON DECKING: 1,401

V. ILLUSTRATIONS

During the infrared survey of the roof, thermal data was recorded via the in-camera digital image recorder and later processed to create the following thermograms. Each set of photographs depicts one sample area as a colorized thermogram, black and white thermogram, and a visible light photo.

The colorized thermogram depicts moisture affected components, *if any*, as changes in colors. The colors white, yellow and red generally indicate the wettest materials. Blues, purple and black indicate dry components.

The black and white thermogram depicts moisture saturation conditions as shades of gray. The whitest areas generally indicate the wettest substrate. The darkest portions or black indicates dry roofing. These calibrations were set using readings of wet and dry materials. When required, moisture meter test probes or core samples are taken to verify and confirm the images seen by the infrared camera.

The visible light photographs are generally taken from the same location as their corresponding thermograms and depict a similar field of view.

A roof drawing is presented prior to the thermograms and photos, depicting the roof layout, and the location of the moisture damaged anomalies, if any.

Please note: Only a sampling of images are recorded for this report. Many of the smaller anomalies, caused by single punctures appear similar.

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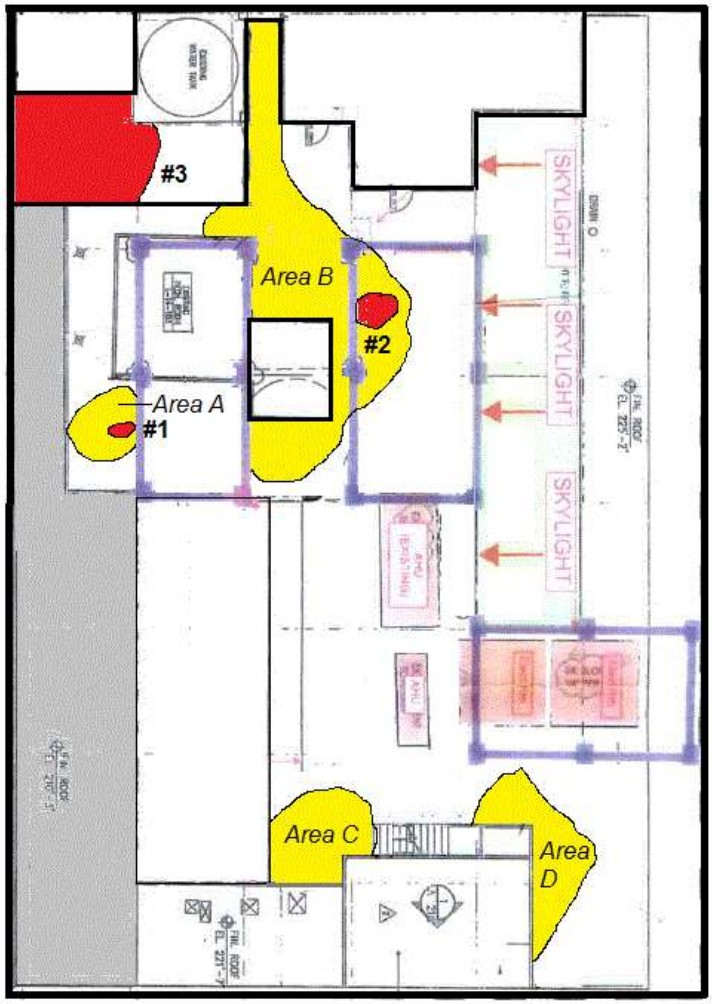


Wet Insulation

Moisture on Deck-Below Insulation

Core Sample

Spectrum IR Services, Inc.

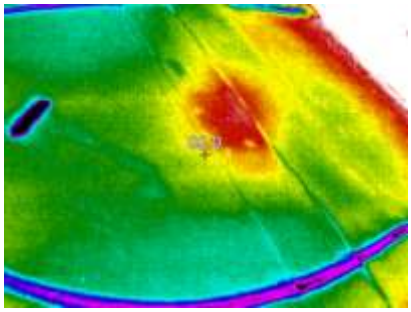
Infrared Roof Moisture Surveys
Masonry Wall Scans
Electrical Component Surveys

Project: [redacted]

Date: [redacted]

Warmest Surface Temperatures.....Coolest Surface Temperatures

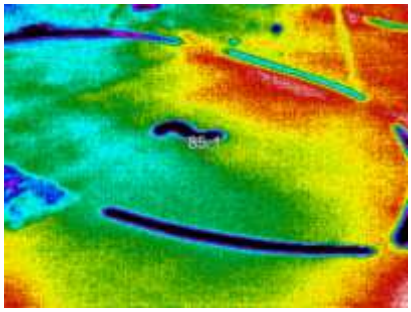
Anomaly #1, Area A



Color Thermogram | Grayscale Thermogram | Visible Light Photograph

Comments: A small area of wet insulation is seen as the colors red and yellow, and as lighter shades of gray in the BW image. The damaged isocyanurate insulation is marked with a solid line.

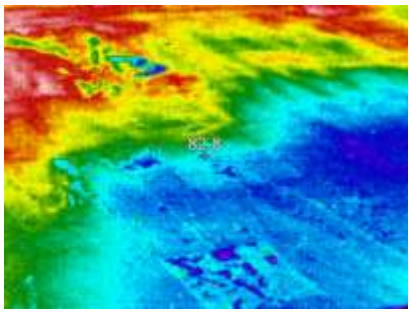
Anomaly #2, Area B



Color Thermogram | Grayscale Thermogram | Visible Light Photograph

Comments: A number of repair patches were seen at this anomaly area. The wet insulation is located within Area B, the largest area of moisture detected on the concrete decking.

Anomaly #3

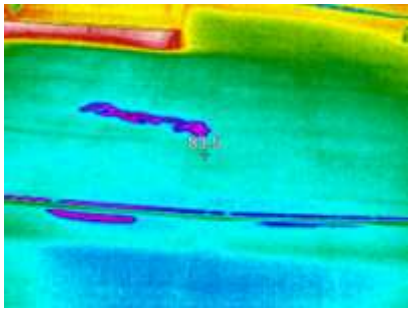


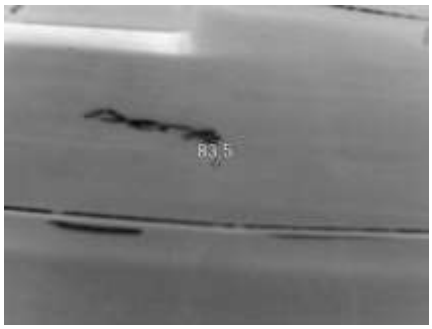
Color Thermogram | Grayscale Thermogram | Visible Light Photograph

Comments: 100% saturated insulation is clearly seen in this thermogram.

Warmest Surface Temperatures.....Coolest Surface Temperatures

Area C

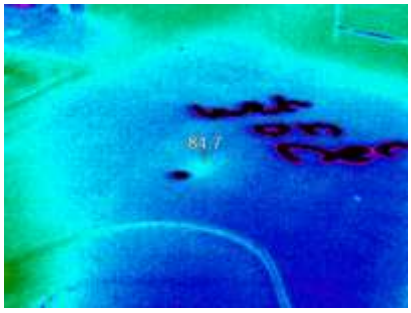




Color Thermogram | Grayscale Thermogram | Visible Light Photograph

Comments: Although wet insulation is not seen with the infrared camera, the Tramex Moisture Meter detected moisture down on the decking, 4" below the surface.

Area D



Color Thermogram | Grayscale Thermogram | Visible Light Photograph

Comments: Damage to the membrane, repaired with caulking was seen at this area. Moisture was detected with the Tramex Moisture Meter. Insulation appears to be dry at this time.

VI. INFRARED CAMERA SPECIFICATIONS

Camera:	FLUKE TiR32
Detector Type:	Uncooled Microbolometer Focal Plan Array (320x240 pixels)
Spectral Band:	8µm to 14µm (long wave)
Thermal Sensitivity:	0.040°C at 30°C target temp (40mK)
Visible Light Camera:	2 megapixel
Spatial Resolution:	1.25 mRad
Temperature Measurements:	-20° C to 150° C
Accuracy:	±2°C
Measurement Capability:	Full frame
Optics:	Standard- 23°x17° Telephoto- 11.5°x8.7° Wide Angle- 46°x34°
Battery Type:	12-Volt Lithium-ion
Storage Medium:	SD Memory Card
File Formats:	JPEG, JPG, JPE, JFIF, BMP, GIF, DIP, PNG, TIF and TIFF