Lessons Learned From the Chicago-area Roof Reflectance Monitoring Project, 2008-12

by Maciek Rupar
Technical Services Director
National Roofing Contractors Association
Chicago-area Roof Reflectance Monitoring Project, 2008-12

Original purpose:
Provide real-world long-term reflective performance information for comparison with the Municipal Code of Chicago requirement for aged low-slope roof system reflectance
...and comparison with ENERGY STAR® and CRRC ratings

- The Roofing Industry Alliance for Progress—equipment funding
- Chicago Roofing Contractors Association—roof access
- NRCA Technical Services staff—measurements
Municipal Code of Chicago, Title 18, Chapter 13
Reflectance Provisions for New Roof Construction

Low-slope (roof slope of 2:12 or less) roofs permitted on or after April 22, 2009, shall meet one of the following:

Initial reflectance \( \geq 0.72 \) As determined by the Cool Roof
Three-year installed reflectance \( \geq 0.50 \) Rating Council or ENERGY STAR®

**Exception:** Where more than 50% of total area is covered by a vegetative roof system

Reflectance for balance of roof area \( \geq 0.30 \)

**Exception:** Where the entire roof area is ballasted with a minimum of 15 lbs/sq.ft. of ballast

Reflectance \( \geq 0.30 \)
Reflectance Provisions for Reroofing

Full or partial replacements or retrofits of existing low-sloped (roof slope of 2:12 or less) roofs originally permitted prior to April 22, 2009, shall meet one of the following:

- Initial reflectance \( \geq 0.72 \)  
- Three-year installed reflectance \( \geq 0.50 \)

**Exception:** Where more than 50% of total area is covered by a vegetative roof system

Reflectedance for balance of roof area \( \geq 0.30 \)

**Exception:** Where an existing ballasted roof is replaced with a ballasted roof, one of the following must be met:

(i) Entire roof area is ballasted with a minimum of 15 lbs/sq.ft. of ballast—Reflectance \( \geq 0.30 \)

(ii) Roof is ballasted with less than 15 lbs/sq.ft.—Initial reflectance \( \geq 0.72 \)

- Three-year installed reflectance \( \geq 0.50 \)

**Exception:** Where an existing roof system sloped at ¼:12 or less is replaced with a BUR

- Surfacing aggregate reflectance \( \geq 0.30 \)
- Underlying bitumen exposure \( \leq 5\% \) or total roof area

**Exception:** Where repair or maintenance of an existing roof system is performed to extend its life, the affected portion shall meet

Reflectance minimum \( \) value in effect at the time of original permit
Chicago-area Roof Reflectance Monitoring Project Quick Stats

- ASTM C1549 (portable solar reflectometer method)
- March 2008—September 2012 duration
- Over 6600 readings collected
- 70 roofs surveyed
- Complete record for 34 roofs
- Variety of systems commonly installed in Chicago
- Dead-level to 6:12
Devices & Services Co. Portable Solar Reflectometer
Roof Reflectance Monitoring Protocol

- Roof selection—where we could get access
- Readings from dry roof surfaces; worked around weather
- Surfaces were not cleaned (with one exception)
- D&S Reflectometer AM2 setting used (AM1.5 is specified in CRRC-1)
- Roof reflectance—mean of readings from random locations
- Margin of error for mean roof reflectance calculated using the t statistic at a 95% confidence level
(16) Adhered EPDM, 2:12 slope at age 4.0 (2008)

- Approximately 150 feet from an expressway
- Reflectance decreased from this point forward
Black EPDM

Chart 4  Mean reflectance: Black EPDM membrane

Bars indicate 95% confidence intervals.
Labels indicate age at time of measurement.

(16) EPDM membrane, black, adhered, 2:12 slope

Mean reflectance:

- 3/1/2008
- 8/31/2008
- 3/2/2009
- 9/1/2009
- 3/3/2010
- 9/2/2010
- 3/4/2011
- 9/3/2011
- 3/4/2012
- 9/3/2012
Aluminum coated polymer-modified bitumen cap sheets

Bars indicate 95% confidence intervals. Labels indicate age at time of measurement. Trend lines were added to make the chart easier to read; they are not intended for interpolation.

Mean reflectance: Aluminum coated polymer-modified bitumen cap sheets, different locations

(1) Aluminum coating (fibred) over smooth SBS-modified bitumen cap sheet, 3:12 slope
(2) Aluminum coating (fibred) over smooth APP-modified bitumen cap sheet
(3) Aluminum coating (fibred) over smooth polymer-modified bitumen cap sheet, patchy coverage
(4) Aluminum coating over smooth polymer-modified bitumen cap sheet, deteriorated, poor drainage
(5) Aluminum coating over smooth polymer-modified bitumen cap sheet, deteriorated, 3:12 slope
(6) Aluminum coating over smooth polymer-modified bitumen cap sheet
(7) Aluminum coating (fibred) over smooth polymer-modified bitumen cap sheet, patchy coverage
(8) Aluminum coating (fibred) over smooth polymer-modified bitumen cap sheet, patchy coverage
(9) Aluminum coating (fibred) over smooth APP-modified bitumen cap sheet
(10) Aluminum coating (fibred) over smooth APP-modified bitumen cap sheet

Chart 2
Gravel-surfaced asphalt BURs

(17) Asphalt BUR at age 21.2
Roof slopes to drain to a gutter on left; dirt from ponding along gutter edge

(18) Asphalt BUR at age 17.4
Internal drains
Gravel-surfaced asphalt BURs

Chart 5

Mean reflectance: Gravel-surfaced asphalt built-up roofs (BUR), different locations
White PVC membrane, high-rise building

(20) Main roof at age 4.3 and (21) penthouse at age 4.7
White PVC membranes, high-rise building

Bars indicate 95% confidence intervals. Labels indicate age at time of measurement.

Chart 6  Mean reflectance: White polyvinyl chloride (PVC) membranes, same location
White PVC membranes, well-draining

(23) Barrel roof

(39) 2:12 slope at age 8.2 (2012)
- Adjacent expressway
- Regular foot traffic
White PVC membranes, well-draining

Chart 7  Mean reflectance: White PVC membranes, above-average slope, different locations
White PVC membrane, dome vs. typical slope

(31) Dome and (28) typical slope

Typical slope: (28) Foreground and (29) background
White PVC membrane, dome vs. typical slope

Bars indicate 95% confidence intervals. Labels indicate age at time of measurement. Trend lines were added to make the chart easier to read; they are not intended for interpolation.

Chart 9  Mean reflectance: Older white PVC membranes, same location
White PVC membrane vs. vegetative trays

(34) White PVC roof system with vegetative trays;
(35) visible in the background (no trays)
White PVC membrane vs. vegetative trays

Chart 11  Mean reflectance: White PVC membranes, typical slope, same location
Different reflective membranes, same location

(38) White PVC, ¼:12 design slope; mechanically attached using electromagnetic induction welding technology

Adhered membranes: (36) white PVC, (58) white TPO, (68) white PVDF-surfaced bitumen cap sheet
¼:12 design slope
Different reflective membranes, same location

Bars indicate 95% confidence intervals. Labels indicate age at time of measurement. Trend lines were added to make the chart easier to read; they are not intended for interpolation.

Chart 14  Mean reflectance: Reflective white membranes, same location
White PVC membranes, discolored

(40) ¼:12 design slope

(45) ¼:12 design slope
Reflective TPO membranes

(59) White TPO, ¼:12 design slope, tapered insulation

(60) Tan TPO, 6:12 design slope, gable roofs with internal gutter
Tan TPO membrane, 6:12 slope

Bars indicate 95% confidence intervals. Labels indicate age at time of measurement.
White granule-surfaced polymer-modified bitumen cap sheets

Bars indicate 95% confidence intervals. Labels indicate age at time of measurement. Trend lines were added to make the chart easier to read; they are not intended for interpolation.
Granule-surfaced polymer-modified bitumen cap sheets—white vs. tan

Chart 23  Mean reflectance: Granule-surfaced polymer-modified bitumen cap sheets, same location
Conclusions

- Effective drainage measurably improves retention of roof reflectance
  - Increased slope most effective at improving drainage and moderating reflectance loss but not a cure-all
  - Drainage design, rainfall, rooftop traffic, roof location, roof use are other variables affecting reflective performance of in-service roofs
- Roofs temporarily or periodically measurably recover some reflectance loss because of washing by rain
- Aged reflectance values recorded for roof covering surfaces exposed in service at slopes commonly used in low-slope roof construction were lower than the three-year aged reflectance values available from The ENERGY STAR Roof Products Program and CRRC Rated Products Directory for equivalent materials.
**Recommendations**

Considering the evidence collected:
Reflective roof covering sheets for low-slope applications should be expected to experience higher in-service temperatures than would be expected with the products’ current ENERGY STAR and CRRC three-year aged reflectance values.

CRRC should reconsider its current slope specification of 5 degrees for aging low-slope roof covering materials because it does not reflect common roofing industry practice.