

INSPECTION AND MAINTENANCE OF ROOF ASSEMBLIES

Table of Contents

	Page
1.0 SCOPE	2
1.1 Hazard	2
1.2 Changes	3
2.0 LOSS PREVENTION RECOMMENDATIONS	3
2.1 Introduction	3
2.2 Operation and Maintenance	3
2.2.1 Roof Inspection and Maintenance	3
3.0 SUPPORT FOR RECOMMENDATIONS	5
3.1 Roof Maintenance Program	5
4.0 REFERENCES	10
4.1 FM Global	10
4.2 Other	11
APPENDIX A GLOSSARY OF TERMS	12
APPENDIX B DOCUMENT REVISION HISTORY	13

List of Figures

Fig. 1.1-1 Hail damage to 20-year-old “alligatored” built-up roof	2
Fig. 3.1-1. Debris blocking roof drain	6
Fig. 3.1-2. Clogged roof drain	6
Fig. 3.1-3. Flashing easily lifted (follow appropriate safety procedures when near the roof edge)	7
Fig. 3.1-4. Cuts in PVC cover at the edge of a stress plate	7
Fig. 3.1-5. Mechanically attached PVC cover with lighter areas over plastic stress plates that may indicate plasticizer loss and increase in brittleness	7
Fig. 3.1-6. Shrinkage and embrittlement of a thermoplastic single-ply roof with flaking of an incompatible asphaltic coating	8
Fig. 3.1-7. Rubber walkway pad secured to the PVC membrane with heat-welded tabs	8
Fig. 3.1-8. Severe blistering of a built-up roof	9
Fig. 3.1-9. Built-up roof with discolored area where water ponds (note exposed roof areas missing gravel) .	9
Fig. 3.1-10. Scrim showing where gravel is missing	10
Fig. 3.1-11. Spray polyurethane foam flaking and delaminating	10
Fig. 3.1-12. Corroded and deformed roof clip on standing seam roof in coastal area	11

1.0 SCOPE

This data sheet provides guidelines for establishing an effective loss prevention inspection and maintenance program for existing roof assemblies.

For repair of wind-damaged roofs, or repair of unadhered areas of adhered roofs, refer to Data Sheet 1-30, *Repair of Wind-Damaged Single-Ply and Multi-Ply Roof Assemblies*.

For new or re-cover roofs, see Data Sheet 1-28, *Wind Design*; Data Sheet 1-29, *Above-Deck Roofing Components*; Data Sheet 1-31, *Panel Roof Systems*; Data Sheet 1-34, *Hail Damage*; and Data Sheet 1-54, *Roof Loads for New Construction*.

1.1 Hazard

Roof assemblies are critical to keeping the weather (water, wind, snow, cold, and heat) out of buildings, and assisting in maintaining proper interior conditions (e.g., temperature, humidity, and cleanliness) in order to protect a building's contents and maintain operations. A comprehensive roof inspection and maintenance program is vital to ensure roofs continue to perform these functions.

Inspections are recommended semi-annually and before and after storms with high winds or heavy rain because roof damage such as cuts or holes can occur anytime. The weather, heat, water, ozone, and the sun's UV light deteriorate roofs as they age, lowering their wind, hail, and water resistance. Single-ply, multi-ply, and spray polyurethane foam roofs can also become brittle and prone to damage from much smaller hail and lower wind speed than they were originally tested to resist. All roofs eventually require replacement but they can last longer with a comprehensive inspection and maintenance program.

Figure 1.1-1 shows damage to a more than 20-year-old four-ply built-up roof from only 1 in. (25 mm) diameter hail, which has "chipped" parts of the asphalt flood coat that has "alligatored" as a result of age and loss of solvents (resulting in brittleness and loss of adhesion to the fiberglass felts). The alligatored appearance is a clear indication that the roof has aged and is vulnerable to damage from small hail..

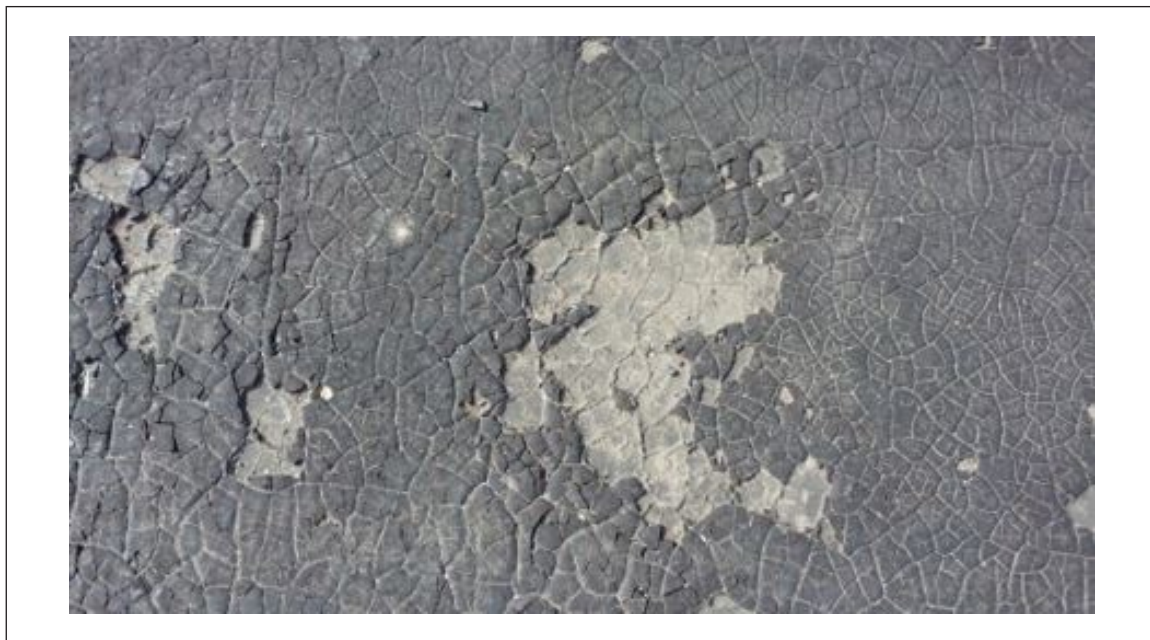


Fig. 1.1-1 Hail damage to 20-year-old "alligatored" built-up roof

1.2 Changes

July 2020. Interim revision. Minor editorial changes were made in Section 4.2.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

2.1.1 Use FM Approved equipment, materials, and services whenever they are applicable and available. For a list of products and services that are FM Approved, see the *Approval Guide* and *RoofNav*, as applicable.

2.1.2 Have the building owner's qualified representative provide thorough supervision during all roof work to ensure quality of workmanship and adherence to FM Approved standards and project specifications. Follow DS 1-52, *Field Verification of Roof Wind Uplift Resistance*.

2.1.3 When reroofing, remove only that portion of roof covering and insulation that can be replaced the same day. This will reduce possible wetting of the insulation and limit water damage.

2.1.4 Consult with the membrane manufacturer and/or warrantor prior to making repairs or conducting hail impact or other testing that requires removing a section of the roof. A reinspection by the manufacturer may be needed in order to maintain warranty coverage.

2.1.5 Use repair methods that do not require a torch whenever possible, such as using cold-applied adhesives when repairing base flashings. If torch-applied repairs are made, adhere to the recommendations in DS 1-33, *Safeguarding Torch-Applied Roof Installations*.

2.1.6 Provide at least one 10 lb (4.5 kg) ABC multipurpose dry-chemical portable fire extinguisher within 20 ft (6.1 m) horizontal travel distance of torch-applied roofing equipment. Use charged hose lines or additional extinguishers for roof areas larger than 10,000 ft² (929 m²). Adhere to the recommendations in DS 1-0, *Safeguards During Construction, Alteration, and Demolition*, and DS 1-33, *Safeguarding Torch-Applied Roof Coverings*.

2.1.7 Follow safety precautions and jurisdiction rules when on roofs and using ladders. Maintain a safe distance from roof edges, skylights, and open roof hatches.

2.2 Operation and Maintenance

2.2.1 Roof Inspection and Maintenance

2.2.1.1 Provide a roof inspection and maintenance program that includes recommendations 2.2.1.2 to 2.2.1.11.

2.2.1.2 Maintain written or computer-based records with pictures of problem areas. Consider using an Engineered Management System (EMS) for large facilities with many different roofs.

2.2.1.3 Secure roof access points, limit roof access to authorized personnel, and follow the membrane manufacturer's restrictions on cold weather access.

2.2.1.4 Do not allow foot traffic on unreinforced PVC membranes or other roofs showing signs of embrittlement or severe deterioration unless the temperature is at least 60°F (15.6°C).

2.2.1.5 If it is not practical to eliminate foot traffic, provide alternative paths or walkways to roof-mounted equipment and the like.

2.2.1.6 Reinstall fasteners when maintenance is provided on roof-mounted equipment that requires removal of components such as hoods and related fasteners.

2.2.1.7 Inspect roofs, flashing, drains, and roof-top equipment on a regular schedule but at least semiannually and before and after storms with high winds or heavy rain or hail.

2.2.1.8 For locations exposed to hurricanes, cyclones, typhoons, or severe local winds, see FM Global Publication P9308, *Emergency Checklist: Wind*.

2.2.1.9 Have a qualified person conduct inspections of all areas, with special focus on roof areas subject to higher temperatures or UV rays such as occur from reflected sunlight within 10 ft (3 m) of glass windows

or metal walls; areas that are subject to ponding water or have sediments; areas near exhaust vents, especially those with chemicals, grease, or oil; and heavily trafficked areas such as roof access points and paths to rooftop equipment.

2.2.1.10 Follow manufacturer's guidelines and inspect and correct the following deficiencies (see Section 3.1 for a list of publications with roof inspection checklists and detailed inspection information):

- A. Leaks on the underside of the roof deck, ceilings, and interior and exterior walls. Roof components above any leaks should be carefully inspected, although the source of a roof leak can be far from where the inside damage is visible.
- B. Flashing that has loose or missing fasteners, is loose (see Figure 3.1-3), bent, or missing; missing joint covers; holes or corrosion; and cracked or weathered sealants. Also loose, open, or deteriorated stripping material sealing the roof to the flashing.
- C. Loose rooftop equipment and lightning protection cables and fasteners missing from rooftop equipment.
- D. Vegetation, including leaves and branches; debris, including nails and leftover construction materials; and tree branches overhanging the roof.
- E. Debris blocking or restricting roof drains (see Figures 3.1-1 and 3.1-2), scuppers, gutters and downspouts. Check for missing debris covers over interior roof drains.
- F. Improper roof drainage, including ponding (see Fig. 3.1-9).
- G. HVAC condensate or other liquids discharging onto roof surfaces.
- H. Unsecured roof access points.
- I. Single-ply membranes for holes, cuts (inspect closely at stress plates where the membrane can be cut, including by hail; see Figure 3.1-4), ridges, open seams, crazing, erosion, deterioration or the scrim (reinforcement) showing, screws pulling out of the deck, unsupported areas of the membrane (caused by warping, bowing, or shrinkage of insulation boards), unbonded membranes in adhered roofing systems (billowing when windy), improper ballast distribution and coverage of the membrane, peeling or flaking of coatings (see Figure 3.1-6), or non-fleece-backed PVC roof covers installed directly (i.e., without a separating layer) over asphalt or polystyrene insulation.

Additional signs of possible embrittlement as follows:

- 1. Stretching or tightening of the membrane. Usually noticeable at the edges and seams, flashings, roof penetrations or walkway pads (see Figure 3.1-7).
 - 2. Darkening of the membrane, with originally white membranes turning yellow or brown, or areas over plastic stress plates becoming lighter (see Figure 3.1-5). Plastic stress plates can cause increased plasticizer migration in PVC roofs.
- J. Multi-ply roof covers (built-up or modified bitumen): Punctures, cracks, open roof seams, blisters (see Figure 3.1-8), wrinkles, ridges, missing granules, fastener back-out, unadhered areas, continuous distribution of aggregate (if present), and continuous and nondeteriorated surface coatings (if present). Also deteriorating felts (e.g., scrim is showing as in Figure 3.1-10), and alligatored surfaces (see Figure 1.1-1).
 - K. Spray polyurethane foam roofs for pinholes, cracks, splits, blisters, or erosion, peeling or deterioration of the coating or polyurethane foam (Fig. 3.1-11). It is critical that the elastomeric top coat over the foam is in good condition or the foam will deteriorate.
 - L. Asphalt shingles: Missing, cracked, or loose shingles, missing or corroded fasteners, loss of surface granules, or the reinforcing matt is showing or other deterioration.
 - M. Metal roof systems: Missing or loose fasteners; fasteners with missing or deteriorated flexible gaskets; panels that have holes, cracks, severe deformation or severe corrosion; panel clips with severe corrosion (see Figure 3.1-12) or damage to seams that can leak water.
 - N. Clay, concrete, and slate tile roofs: Missing, cracked, or loose tiles; missing or corroded fasteners; spalling, flaking, erosion or other deterioration of the tiles. Discoloration is usually not a concern.
 - O. Crushed or water-damaged insulation (does not feel firm).

2.2.1.11 Review inspection reports and repair or monitor deficiencies as follows:

A. Promptly correct the following:

1. Deficiencies that lower the wind resistance of the roof, such as flashing deficiencies, membrane deficiencies including unadhered sections of adhered membranes, screws pulling out, deteriorated membranes, and wet insulation.
2. Deficiencies that lower hail resistance, such as embrittled or deteriorated roofs.
3. Deficiencies that can lead to roof collapse, such as clogged drains, roof debris, and overhanging vegetation.
4. Deficiencies that allow water into the roof or building, such as holes, cuts, or missing roof shingle or tiles.

B. Re-roof or re-cover roofs that are embrittled, deteriorating, or have deficiencies over a large area with an FM Approved roof assembly (see Data Sheets 1-28, 1-29, 1-31, 1-34, or 1-49). These conditions severely reduce the roof's resistance to hail, wind, and rain storms and become more probable as the roof assembly approaches the end of its warranty period or expected service life.

C. Engage a registered roof consultant (RCC, as certified by International Institute of Building Enclosure Consultants, or equivalent outside the United States) if confirmation of membrane condition is needed (see Section 2.2.2).

D. See DS 1-49, *Perimeter Flashing*, for securing loose flashing, and DS 1-30, *Repair of Wind-Damaged Single-And Multiply Roof Systems*, for securing loose adhered membrane roofs, and repair roofs following the manufacturer's instructions and National Roofing Contractors Association guidelines.

E. Monitor other deficiencies, such as small blisters and minor crazing.

F. Engage a registered roof consultant (RCC, as certified by International Institute of Building Enclosure Consultants, or equivalent outside the United States) to inspect and assess the condition of any non-felt-backed PVC roof covers installed directly (i.e., without a separating layer) over asphalt or polystyrene insulation (see Section 2.2.2).

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Roof Maintenance Program

A comprehensive roof maintenance program is critical to ensuring roofs can perform their primary function of keeping weather out of buildings, especially when subjected to severe wind, hail, rain, and snow storms. It is also usually required in order to maintain the warranty.

There are many studies showing that following the manufacturer's recommended inspection and repair schedule results in longer roof life and overall lower roof costs. For the lowest costs, it is especially important to keep the insulation dry and in good condition. Wet insulation reduces the roof's wind, hail, and thermal resistance, and greatly increases repair and roof replacement costs. If the insulation is in good condition, a roof re-cover can often be installed, saving substantial insulation replacement and disposal costs. It is especially important to thoroughly inspect membranes with new formulations for deficiencies, including premature deterioration of the membrane.

Many manufacturers provide inspection and maintenance guidelines along with inspection forms. Trade organizations and the US Army Corps of Engineers provide good resources with roof inspection checklists and detailed inspection criteria. The US Army Corps of Engineers' publications include pictures of many deficiencies that are used to determine a roof condition index (RCI) from failed to excellent. It does not take into account the age of the roof, which can reduce its strength and increase its brittleness.

The following resources provide roof inspection and maintenance information:

- ARMA/NRCA Manual for Inspection & Maintenance of Built-Up and Modified Bitumen Roof Systems.
- Concrete and Clay Roof Tile Installation Manual (available online).
- US Army Corps of Engineers (available online):
 - Evaluation of Sprayed Polyurethane Foam Roofing and Protective Coatings

- Membrane and Flashing Condition Indexes for Built-Up Roofs - Volume II: Inspection and Distress. CERL-TR-M-897-13-2
- ROOFER: Membrane and Flashing Condition Indexes for Single-Ply Membrane Roofs-Inspection and Distress Manual. CERL-TR-FM-93-11
- Membrane and flashing condition indexes for modified bitumen roofs: inspection and distress manual
- Spray Polyurethane Foam Roof Systems Maintenance Manual. SPFA-127 (available online)
- SPRI/NRCA Manual of Roof Inspection, Maintenance, and Emergency Repair of Existing Single-Ply Roofing Systems

Eventually even the best-maintained roofs will require replacement, with the average useful life for most single-ply and multi-ply roof covers being between 14 and 18 years, and minimum service lives between 7 and 10 years (Cash 2006). Roof life is affected by many factors, including roof type, quality, installation, maintenance, and weather conditions.



Fig. 3.1-1. Debris blocking roof drain



Fig. 3.1-2. Clogged roof drain



Fig. 3.1-3. Flashing easily lifted (follow appropriate safety procedures when near the roof edge)



Fig. 3.1-4. Cuts in PVC cover at the edge of a stress plate



Fig. 3.1-5. Mechanically attached PVC cover with lighter areas over plastic stress plates that may indicate plasticizer loss and increase in brittleness



Fig. 3.1-6. Shrinkage and embrittlement of a thermoplastic single-ply roof with flaking of an incompatible asphaltic coating



Fig. 3.1-7. Rubber walkway pad secured to the PVC membrane with heat-welded tabs



Fig. 3.1-8. Severe blistering of a built-up roof



Fig. 3.1-9. Built-up roof with discolored area where water ponds (note exposed roof areas missing gravel)



Fig. 3.1-10. Scrim showing where gravel is missing



Fig. 3.1-11. Spray polyurethane foam flaking and delaminating

4.0 REFERENCES

4.1 FM Global

Data Sheet 1-28, *Wind Design*

Data Sheet 1-29, *Above-Deck Roof Components*

Data Sheet 1-30, *Repair of Wind Damaged Single-Ply and Multi-Ply Roof Systems*

Data Sheet 1-31, *Panel Roof Systems*

Data Sheet 1-34, *Hail Damage*

Data Sheet 1-54, *Roof Loads for New Construction*

Emergency Checklist: Wind (P9807)

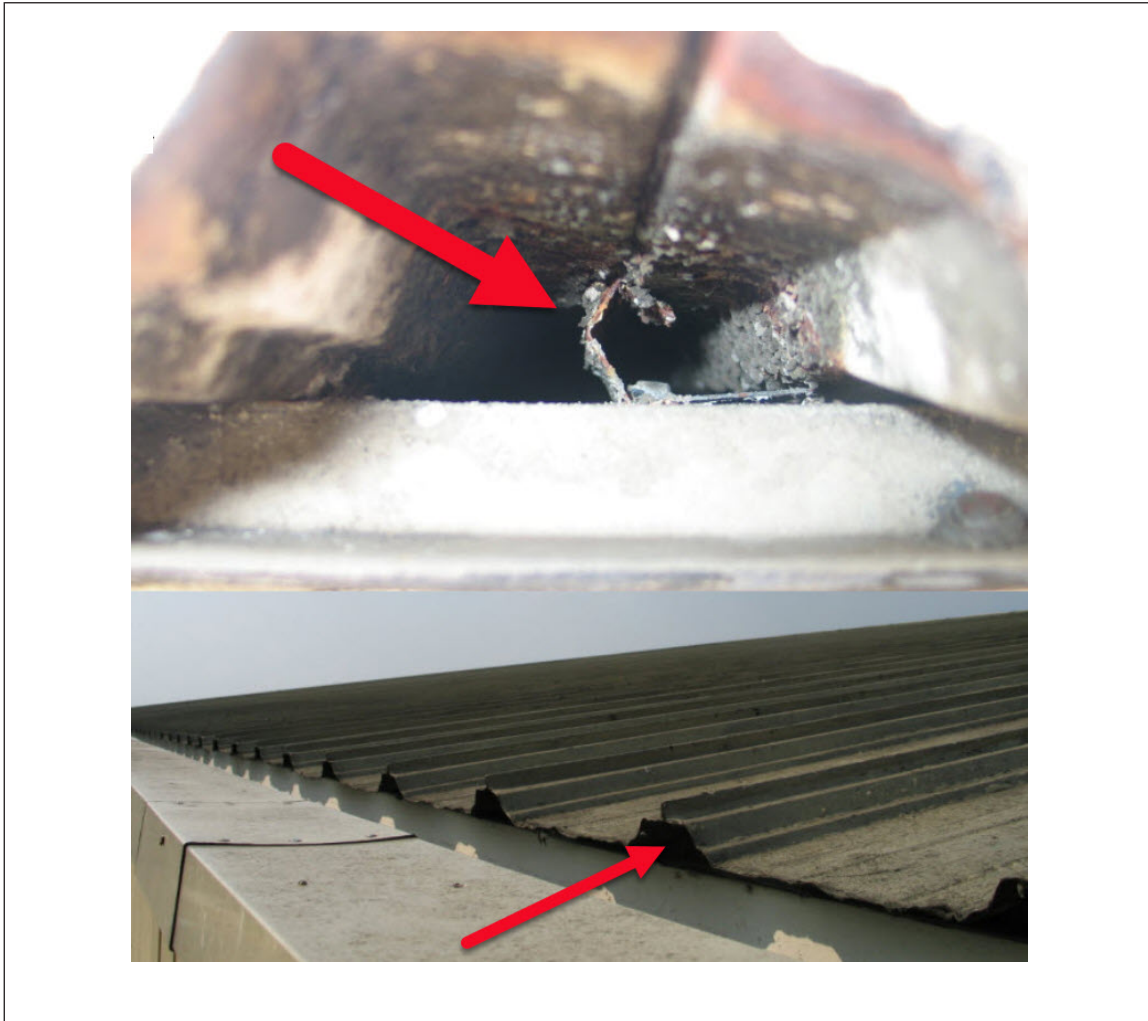


Fig. 3.1-12. Corroded and deformed roof clip on standing seam roof in coastal area

FM Approvals LLC, *Test Procedure, Test Method for Determining the Susceptibility to Hail Damage of Roof Coverings*. June 2017.

FM Approvals LLC, *Test Standard for Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls*, ANSI FM 4473, 2011.

RoofNav, an online resource of FM Approvals for roofing professionals

4.2 Other

Asphalt Roofing Manufacturers Association (ARMA) and the National Roofing Contractors Association (NRCA). *ARMA/NRCA Manual for Inspection & Maintenance of Built-Up and Modified Bitumen Roof Systems*. 1996.

Cash, Carl, G. "2005 Roofing Industry Durability and Cost Survey." *Proceedings of the RCI 21st International Convention*. Roof Consultants Institute, 2006.

National Roofing Contractors Association (NRCA). *NRCA Repair Manual for Low-Slope Membrane Roof Systems*.

Rosenfield, Myer J. Evaluation of Sprayed Polyurethane Foam Roofing and Protective Coatings. Technical Report M-297. Construction Engineering Research Laboratory, US Army Corps of Engineers (USACE), 1981. <http://www.dtic.mil/dtic/tr/fulltext/u2/a109696.pdf> (accessed April 25, 2018).

Single Ply Roofing Institute (SPRI) and the National Roofing Contractors Association (NRCA). *SPRI/NRCA Manual of Roof Inspection, Maintenance, and Emergency Repair of Existing Single-Ply Roofing Systems*.

Spray Polyurethane Foam Alliance (SPFA). *Spray Polyurethane Foam Roof Systems Maintenance Manual SPFA-127.2015*.

Tile Roofing Institute & Western States Roofing Contractors Association. *Concrete and Clay Roof Tile Installation Manual*. 2015. <https://tileroofing.org/resources/installation-guides> (accessed April 30, 2020).

US Army Corps of Engineers (USACE). *Membrane and Flashing Condition Indexes for Built-Up Roofs Volume II: Inspection and Distress*. CERL-TR-M-897-13-2.

US Army Corps of Engineers (USACE) ROOFER: *Membrane and Flashing Condition Indexes for Single-Ply Membrane Roofs-Inspection and Distress Manual*. CERL-TR-FM-93-11.

US Army Corps of Engineers (USACE). *Membrane and Flashing Condition Indexes for Modified Bitumen Roofs: Inspection and Distress Manual*. ERDC/CERL TR-10-05.

US Army Corps of Engineers (USACE). ROOFER Inventory Procedures and Inspection Manual for Metal Panel Roofing. ERDC-TR-12-15.

APPENDIX A GLOSSARY OF TERMS

Crazing: Development of fine cracks on the surface of single-ply membranes that do not go through the membrane.

Chlorosulfonated polyethylene (CSPE or CSM) roof membrane: A rubber-like thermoset material, based on high-molecular-weight polyethylene with sulphonyl chloride.

Ethylene propylene diene terpolymer (EPDM) roof membrane: A thermoset membrane of ethylene, propylene and diene. Those meeting ASTM D4637 have EPDM that is greater than 95% of the polymer content. May be unreinforced or reinforced. Unreinforced membranes must be fully adhered or ballasted.

FM Approved: Products, roof assemblies, and services that have satisfied the criteria for Approval by FM Approvals. Refer to the *Approval Guide* or *RoofNav*, online resources of FM Approvals, for a complete listing of products and services that are FM Approved.

Hail size: Mean diameter of hail (not the maximum distance between two protrusions).

Heat welding: A method of melting and fusing together the overlapping edges of separate sheets or sections of polymer modified bitumen, thermoplastics, or some uncured thermoset roofing membranes by the application of heat and pressure.

Ketone ethylene ester (KEE): A polymer used as the main polymer in KEE roofing and as a lesser polymer in many PVC roof membranes.

Ketone ethylene ester (KEE) membrane roofing: Thermoplastic roof membrane where the main polymer is KEE. Membranes meeting ASTM D6754 have KEE polymer content that is minimum 50% by weight of the total polymer and are reinforced with fabric.

Maintenance coating: A liquid applied product with or without reinforcements over a functioning roof system.

Moderate hail hazard area: Areas in which the hail size does not exceed 1.75 in. (44 mm) for the 15-year mean recurrence interval (MRI). This area is shown for the contiguous United States as "Moderate" in the Hailstorm Hazard Map of the Contiguous United States in DS 1-34, *Hail Damage*.

Polyvinyl chloride (PVC): A thermoplastic polymer prepared from vinyl chloride. PVC can be compounded into flexible and rigid forms through the use of plasticizers, stabilizers, fillers, and other modifiers. Rigid forms are used in pipes; flexible forms are used in the manufacture of sheeting and roof membrane materials.

Polyvinyl chloride (PVC) roof cover: A thermoplastic roof membrane where the main polymer is PVC. Membranes meeting ASTM D4434 have PVC polymer content greater than 50% of the total polymer content and are reinforced.

Roof area: A single roof area where the installation of above deck components is constant, the deck type is the same, the above deck components are installed at the same time and as bounded by the roof outside edge(s), expansion joints, roof area dividers or parapet walls.

Roof area divider: A break in the continuity of above deck roof components only, where the roof cover is flashed to secured wood nailers on each side.

Roof coating: A roof coating is a layer of liquid material applied to a surface for protection or appearance

Severe hail hazard area: Areas in which the hail size exceeds 1.75 in. (44 mm) but does not exceed 2 in. (51 mm) for the 15-year mean recurrence interval (MRI). This area is shown for the contiguous United States as “Severe” in the Hailstorm Hazard Map of the Contiguous United States in DS 1-34, *Hail Damage*.

Thermoplastic: Materials that soften when heated and harden when cooled. This process can be repeated provided the material is not heated above the point at which decomposition occurs.

Thermoplastic polyolefin (TPO) roof membrane: A thermoset membrane composed of ethylene and higher alpha-olefin polymers, copolymers, and their mixtures. These materials hose meeting ASTM D6878 thereof in amounts greater than 50% by weight of the total polymer content and contain reinforcing fabrics or scrim.

Thermoset: Materials that harden or set irreversibly when heated. This usually occurs during the manufacturing process. Thermoset roof membranes cannot be heat welded.

Very severe hail hazards area: Areas in which the hail size exceeds 2 in. (51 mm) for the 15-year mean recurrence interval (MRI). This area is shown for the contiguous United States as “Very Severe” in the Hailstorm Hazard Map of the Contiguous United States in DS 1-34, *Hail Damage*.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

July 2020. Interim revision. Minor editorial changes were made in Section 4.2

April 2019. Minor editorial revisions were made.

January 2019. This document has been completely revised. The following major changes were made:

- A. Changed the title from *Existing PVC Roof Covers* to *Inspection and Maintenance of Roof Assemblies*.
- B. Added a recommendation to create an inspection and maintenance program for all roofs, and provided details on what to include.

May 2000. The document was reorganized to provide a consistent format.