

REPAIR OF WIND-DAMAGED SINGLE- AND MULTI-PLY ROOF SYSTEMS

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1.0 SCOPE

This data sheet addresses the repair of single- and multi-ply roof systems that have minor wind damage, usually from less-severe windstorms. These roof covers might have small tears or may have delaminated from the insulation, or other parts of the roof assembly may have lifted from the roof deck without major damage to the uplifted components. Damage from peeled or severely cut roof covers with cracked and wet insulation that occur from severe wind storms and tropical cyclones require replacement. Repairs outlined in this document do not evaluate the adequacy of the uplift resistance of the roof assembly.

1.1 Changes

February 2020. Minor editorial changes were made to reflect the latest version of Data Sheet 1-28. This includes renaming the field, perimeter, and corner roof areas as Zone 1, Zone 2, and Zone 3, respectively, and adding the new Zone 1' roof area. Guidance for Maximum 8 in. (200 mm) screw spacing was added to Table 2.2.2.3-1.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

2.1.1 Address severely wind-damaged roof areas by providing full re-roofing or re-covering in accordance with RoofNav; Data Sheet 1-28, *Design Wind Loads*; and Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*.

2.1.2 Use FM Approved equipment, materials, and services whenever they are applicable. For a list of products or services that are FM Approved, see RoofNav, an online resource of FM Approvals.

2.1.3 All FM Approved materials are required to have the Approval mark on the packaging or the material itself. Materials without proper labeling are not FM Approved and should not be accepted.

2.1.4 Provide thorough supervision by the building owner's qualified representative during all roof repairs to ensure quality of workmanship and adherence to FM Approved standards and project specifications. For tropical cyclone-prone regions in which the wind speed is ≥ 100 mph (45 m/s), see DS 1-52, *Field Verification of Roof Wind Uplift Resistance*.

2.1.5 During permanent repairs, remove only that portion of roof covering and insulation that can be replaced the same day. This will reduce additional wetting of the insulation and limit additional water damage.

2.1.6 Consult with the membrane manufacturer prior to making permanent repairs. A re-inspection by the manufacturer may be needed to maintain warranty coverage.

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

2.1.8 Provide a minimum of two 10 lb (4.5 kg) ABC multipurpose dry chemical portable fire extinguishers within 20 ft (6.1 m) horizontal travel distance of the repair area and adhere to the recommendations in DS 1-0, *Safeguards During Construction, Alteration, and Demolition*.

2.2 Construction and Location

2.2.1 Damage Assessment and Emergency Repairs

2.2.1.1 Make emergency or temporary repairs to the roof as soon as it is safe to do so.

2.2.1.2 Determine the cause and extent of the roof failure. Inspect roof areas that aren't visibly damaged. Roof cuts or uplift testing may be needed. See DS 1-52.

2.2.2 Permanent Repairs

2.2.2.1 General

2.2.2.1.1 Remove all wet, damaged, and cracked insulation, dry the deck, and repair the roof system based on the type of roof and damage noted in this data sheet.

2.2.2.1.2 Follow manufacturer's repair procedures and additional guidance given in the NRCA *Repair Manual for Low-Slope Membrane Roof Systems*, but adhere to this data sheet for fastener spacing. Consider the expected remaining life of the roof system.

2.2.2.2 Flashing Damage

2.2.2.2.1 Push perimeter flashing that is not severely damaged back into place and secure with screws and rubber washers into the lower third of the flashing per Data Sheet 1-49. Do not use nails. This applies to flashing without hook strips or cleats that may be bent outward from the face of the wall.

2.2.2.2.2 Replace flashing systems that are severely damaged with an FM Approved system selected using RoofNav and following DS 1-49.

2.2.2.3 Ballasted Single-Ply Membranes

2.2.2.3.1 Excessive Ballast Scour: More than 50 ft² (5 m²) with No Roof Cover Damage

2.2.2.3.1.1 Evaluate the adequacy of the size and weight of ballast in all roof areas in accordance with DS 1-29, *Above-Deck Roof Components*.

2.2.2.3.1.2 Where damage was caused by a tropical cyclone, consider an enhanced wind design in accordance with DS 1-28.

2.2.2.3.1.3 Cut the membrane to reset any displaced insulation and then repair the roof membrane according to the manufacturer's instructions.

2.2.2.3.1.4 Where found deficient per 2.2.2.3.1.1, improve the wind uplift resistance of the roof cover by doing **one** of the following:

A. Provide ballast of the recommended size and weight per DS 1-29, *Above-Deck Roof Components*. Ballast should follow specifications in DS 1-29 and only be used if the load capacity of the roof is adequate as determined by a registered civil or structural engineer. Undersized ballast can be spread in the roof field area **Zones 1 and 1' (when present)** if it does not expose windows.

B. Replace the stone ballast in deficient **Zone 1 or Zone 3** areas with beveled or strapped concrete pavers per DS 1-29, *Above-Deck Roof Components*.

C. Remove ballast in deficient areas and fasten the membrane to the deck by following all of the steps below (ballast can be permanently removed from fastened areas if it is not required for exterior fire exposure. Refer to DS 1-42 when maximum foreseeable loss [MFL] walls are present):

1. Fasten the membrane to **one** of the following:

- a. To the deck in a manner equivalent to the FM Approved mechanically fastened version of the membrane using FM Approved fasteners and batten bars or stress plates. Make **Zone 2 and Zone 3** fastening enhancements per Data Sheet 1-29.
- b. To structural concrete or minimum 22 ga (0.0295 in.; 0.749 mm) thick decks with FM Approved batten bars if the generic type of membrane is not known. Use fasteners FM Approved for the particular deck with the spacing per Table 2.2.2.3-1 when no. 15 (0.26 in., 6.6 mm) diameter screws are used.

2. For steel decks, install rows of fasteners perpendicular to steel deck ribs with fasteners engaging the top flanges of the steel deck. Seal over the batten bars and fasteners in a manner consistent with an FM Approved mechanically fastened system. For some membrane types, such as chlorosulfonated polyethylene, the sealing method used for a new installation may not be possible for a weathered membrane.

3. Install batten bars around the repair area (between the mechanically fastened and ballasted areas and around roof drains and other roof penetrations in the mechanically fastened areas. Secure the batten bar with screws spaced 6 in. (152 mm) on-center. Seal the battens with a cover strip.

Table 2.2.2.3-1 Maximum Fastener Row and Screw Spacing to Repair Single-Ply Membranes Using FM Approved Min. No. 15 (0.26 in., 6.5 mm) Screws in Concrete or Min. 22-gauge (0.0295 in., 0.75 mm) Steel Deck

Zone 1 Design Pressure	Zone 1 FM Roof Rating	Maximum Screw Spacing in Batten Bars ¹	Maximum Spacing Between Batten Bars Rows			
			Zone 1'	Zone 1	Zone 2	Zone 3
Zone 1 ≤ 45 psf (2.1 kPa)	FM Roof Rating ≤ 90	6 in. (150 mm)	72 in. (1800 mm)	54 in. (1400 mm)	36 in. (900 mm)	24 in. (600 mm)
45 psf (2.1 kPa) < Zone 1 ≤ 85 psf (6.8 kPa)	90 < FM Roof Rating ≤ 170		48 in. (1200 mm)	30 in. (750 mm)	18 in. (500 mm)	12 in. (300 mm)
Zone 1 ≤ 45 psf (2.1 kPa)	FM Roof Rating ≤ 90	8 in. (200 mm)	72 in. (1800 mm)	40 in. (1000 mm)	24 in. (600 mm)	18 in. (500 mm)
45 psf (2.1 kPa) < Zone 1 ≤ 85 psf (6.8 kPa)	90 < FM Roof Rating ≤ 170		36 in. (900 mm)	18 in. (500 mm)	12 in. (300 mm)	12 in. (300 mm)

¹ Use deck rib spacing

2.2.2.3.2 Excessive Ballast Scour: More than 50 ft² (5 m²) with Roof Cover Damage

2.2.2.3.2.1 Repair or replace the roof cover as needed.

2.2.2.3.2.2 Secure a repaired cover in accordance with Recommendation 2.2.2.3.1.

2.2.2.3.2.3 Install new roof covers that are FM Approved and compatible with the existing insulation if the insulation is dry and undamaged, or install a new ballasted system. Since ballasted systems are currently not FM Approved, select a ballasted system using components that are FM Approved for use together in a RoofNav assembly. In lieu of fasteners or adhesives to secure the above-deck components, use ballast per DS 1-29. Also adhere to the recommendations in DS 1-28.

2.2.2.4 Non-Ballasted Roofs

2.2.2.4.1 Adhered Roof Cover Removed (Delaminated) from Insulation or Insulation Facer Removed (Delaminated) from Insulation

2.2.2.4.1.1 Repair roofs with adhered roof covers that are not severely damaged but where the roof cover or insulation facer has delaminated from the insulation and the existing insulation is dry, secure, and in good undamaged condition, with **one** of the following options:

A. Fasten existing single-ply membranes in good condition following Recommendation 2.2.2.3.1.4 part C (becomes a mechanically-fastened single-ply membrane).

B. Fasten existing multi-ply roof covers (BUR and modified bitumen) in good condition on minimum 22 ga (0.0295 in.; 0.749 mm) thick steel decks with fasteners and metal insulation stress plates FM Approved for the deck. Fasteners and stress plates are secured through the top of the existing membrane into the steel deck with a new FM Approved roof membrane installed over the new fasteners in adherence with DS 1-29. Space fasteners according to Table 2.2.2.4-1 when no. 14 (1/4 in. [6.5 mm]) minimum screws are used.

C. Provide a new re-roof (see Appendix A) FM Approved roof assembly from the deck up or FM Approved re-cover roof over the existing roof components if there is no more than one roof and the existing insulation is dry, secure, and in good, undamaged condition. Select an assembly using RoofNav and per DS 1-28 and DS 1-29.

Table 2.2.2.4-1. Repair Fastener Spacing for Existing Multi-ply Roof Covers Using FM Approved Min. No. 14 (1/4 in. [6.5 mm]) Screws and Plates in Min. 22 gauge (0.0295 in., 0.75 mm) Steel Deck^{1,2}

Roof Design Pressure (P_d) in Respective Roof Area, psf (kPa)	Needed Ultimate Pressure (P_u), psf (kPa)	Maximum Area per Fastener, ft ² (m ²)
$P_d \leq 30$ (1.44)	$P_u \leq 60$ (≤ 2.87)	5 (0.46)
30 (1.44) $< P_d \leq 35$ (1.68)	60 (2.87) $< P_u \leq 70$ (3.35)	4.5 (0.42)
35 (1.68) $< P_d \leq 40$ (1.92)	70 (3.35) $< P_u \leq 80$ (3.83)	4 (0.37)
40 (1.92) $< P_d \leq 45$ (2.16)	80 (3.83) $< P_u \leq 90$ (4.31)	3.5 (0.32)
45 (2.16) $< P_d \leq 50$ (2.4)	90 (4.31) $< P_u \leq 100$ (4.79)	3 (0.28)
50 (2.4) $< P_d \leq 65$ (3.11)	100 (4.79) $< P_u \leq 130$ (6.22)	2.5 (0.23)
65 (3.11) $< P_d \leq 80$ (3.83)	130 (6.22) $< P_u \leq 160$ (7.66)	2 (0.19)
80 (3.83) $< P_d \leq 155$ (5.1)	160 (7.66) $< P_u \leq 210$ (10.1)	1.5 (0.14)
115 (5.1) $< P_d \leq 163$ (7.8)	210 (10.1) $< P_u \leq 325$ (15.6)	1 (0.09)
$P_d > 163$ (7.8)	$P_u > 325$ (15.6)	0.5 (0.05)

¹ Use for organic, glass fiber, or polyester felts, or modified bitumen. Do NOT use for single ply membranes.

² Do not include existing securement for the above deck roof components.

2.2.2.4.2 Adhered Roof Cover with Adhered Insulation Uplifted from Roof Deck

2.2.2.4.2.1 Engage a registered roof consultant (RRC, as certified by RCI, Inc.) or equivalent outside the US, to inspect and assess the condition of the above deck components if the roof cover and insulation have been lifted from the deck.

2.2.2.4.2.2 Replace the roof cover and insulation if warranted per 2.2.2.4.2.1. Damaged insulation that was adhered to metal decks with asphalt should be replaced with insulation mechanically fastened to the steel deck according to the FM Approval for the assembly. When a metal deck is not present and asphalt is used, ensure a full (100% deck coverage) mopping of asphalt to adequately secure insulation to non-nailable decks such as structural concrete. Only use strip or spot mop base sheets within the limits of FM Approved systems.

2.2.2.4.3 Mechanically Fastened Base Sheet or Mechanically Fastened Insulation Uplifted from Roof Deck

2.2.2.4.3.1 Provide a new FM Approved roof assembly from the deck up when mechanically fastened base sheets or mechanically fastened insulation is uplifted from the deck. Select using RoofNav and DS 1-28, and install in accordance with DS 1-29.

2.2.2.4.3.2 Conduct pull-out tests on fasteners used with cementitious wood fiber, gypsum, or lightweight insulating concrete decks. Use a fastener density per Data Sheet 1-29.

2.2.2.5 Roof Deck Damage

2.2.2.5.1 Replace wind-damaged roof decks or those showing signs of rot or similar deterioration with properly secured FM Approved roof decks selected using RoofNav and DS 1-29. If the roof deck is damaged due to the interior environment, such as gypsum or cementitious wood fiber decks over a high-humidity occupancy, replace the deck with a deck material tolerant of the occupancy.

2.2.2.5.2 Inspect the securement of the deck for adequacy per DS 1-28 and DS 1-29 if the above-deck components have been removed. If additional deck securement is needed, have it applied in all areas where necessary to reduce the potential for future damage.

2.3 Human Factor

2.3.1 Manage hot work in accordance with Data Sheet 1-33, *Safeguarding Torch-Applied Roof Installations*, and Data Sheet 10-3, *Hot Work Management*.

2.3.2 Include the following in the Property Conservation Program (see DS 10-0, *The Human Factor of Property Conservation*):

A. A list of roofing contractors to make emergency repairs, and

B. A list of any recommended emergency supplies for roof repairs or protecting interior contents. This may include tarpaulins to cover damaged roof areas (only use sand bags to secure tarpaulins if the roof can support the load) or to protect critical equipment or other contents from roof leaks.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Emergency and Temporary Repairs

When wind damage occurs, primary consideration should be given to keeping water out of the building and limiting wetting of the roof insulation. This may involve using tarpaulins secured with wood battens screwed into the roof deck or ballasted with sand bags (if the roof deck can support the weight) or making emergency repairs with caulk, duct tape, or plastic roofing cement for modified bitumen or BUR roofs. Temporary repairs with roof patches may then be needed depending on the extent of damage and whether the roof cover will be repaired or replaced.

3.2 Permanent Repairs

3.2.1 Determine the Damaged Area

Wind can damage roofs in a number of ways. Types of damage include:

- Perimeter flashing components removed or loosened.
- Roof covering and/or insulation removed.
- Roof covering and/or insulation delaminated.
- Roof deck panels dislodged or lifted.
- Roof covering damaged by impact from wind-blown objects.
- Dislodged roof protrusions such as vents and skylights.

The wind damaged area may not be easily visible, especially when the insulation or cover has been delaminated. Field uplift tests (Data Sheet 1-52, *Field Verification of Roof Wind Uplift Resistance*) or test cuts may be needed to determine the damaged area.

3.2.2 Determine Cause of Roof Failure

The cause of the roof failure is needed to determine if the damaged area can be replaced with the same components or if improvements in securement or materials are needed. Undamaged areas may have the same deficiencies that should be scheduled for future improvement.

In many wind losses, roof covering wind damage begins at the perimeter flashing. After the perimeter flashing assembly has failed, the roof cover edge is peeled back by the wind even if there are no deficiencies in the roof assembly. Because of this, it is extremely important that all flashing is inspected on a regular basis and loose flashing secured in adherence with DS 1-49. It should also be inspected and repaired adequately and promptly.

If perimeter flashing was not damaged and a roof component failed at a wind speed much lower than the design wind speed, then there likely is a deficiency in the design or installation of the roof assembly or there has been deterioration in the roof components.

Wind damage to roof insulation and coverings usually begins at or near the windward edge, particularly at the corners, and progresses inward. The damage can take the form of direct uplift or peeling action of the wind working on the unprotected covering after initial damage occurs.

Wind damage can occur to roof systems that have weakened from moisture. Causes of moisture include leaking roof covering, exposure to moisture prior to application of roof cover, and a high-humidity atmosphere below the deck. Prolonged exposure to moisture can result in deterioration of the deck, insulation, and fasteners. These deficiencies may not be apparent until the roof is damaged by wind. If such exposure is suspected, have a moisture survey conducted by a qualified roofing consultant to determine the potential for problems. These deficiencies should be corrected by replacing the wet or deteriorated materials.

Winds occasionally cause adhered base sheets or insulation to delaminate from non-nailable decks (structural concrete, etc.). This has mainly occurred when the base sheets or insulation have been adhered with insufficient ribbons or strips of asphalt. These methods provide only partial contact area. Damage seldom occurs when the components are fully mopped to a primed substrate and adequate flashing is provided.

Items to check to determine the cause of roof failure include the following:

- A. What was the wind speed that caused the damage?

- B. Did flashing damage initiate the roof cover damage?
- C. Did the membrane peel off the insulation or did the membrane and insulation facer delaminate from the insulation?
- D. Did fasteners pull out of the deck or did the insulation or base sheet pull over the fasteners? (Increased fastener density, larger fastener head or plate, or stronger/thicker base sheets or insulation may be needed. Pull-out tests should be run on fasteners used with cementitious wood fiber, gypsum, or lightweight insulating concrete decks. Fastener density is then determined using Data Sheet 1-29.)
- E. Was the insulation wet?
- F. Were the fasteners corroded?
- G. What was the size and weight of the in-place ballast?

3.2.3 Repair Considerations

In reroofing design, several factors should be considered in determining whether or not the existing roof system should be left in place. These factors include, but are not limited to, the following:

- A. The condition of the existing deck and insulation
- B. The dead load capacity of the deck
- C. The need for additional insulation
- D. The extent of damage

If existing materials are to be left in place, the dead load capacity of the roof should be investigated to ensure the deck will not be overstressed. See DS 1-54.

4.0 REFERENCES

4.1 FM

Data Sheet 1-28, *Design Wind Loads*
Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*
Data Sheet 1-32, *Inspection and Maintenance of Roof Assemblies*
Data Sheet 1-33, *Safeguarding Torch-Applied Roof Installations*
Data Sheet 1-42, *MFL Limiting Factors*
Data Sheet 1-49, *Perimeter Flashing*
Data Sheet 1-52, *Field Verification of Roof Uplift Resistance*
Data Sheet 10-3, *Hot Water Management*

Approval Guide, a publication of FM Approvals

4.2 Other

Asphalt Roofing Manufacturers Association, the National Roofing Contractors Association, and SPRI. *Repair Manual for Low-Slope Membrane Roof Systems*

APPENDIX A GLOSSARY OF TERMS

Adhered single-ply membrane: A single-ply membrane adhered to the substrate with an adhesive or asphalt. The insulation itself, if used, may be mechanically attached to the roof deck.

Aggregate: (1) Crushed stone, crushed slag, or water-worn gravel used for surfacing a built-up roof (BUR); (2) any granular mineral material.

Asphalt: A dark brown to black hydrocarbon obtained from petroleum processing.

Ballasted single-ply membrane: Single-ply membranes that are only attached at the roof perimeter and penetrations, and are held in place with ballast consisting of large stones or concrete paver blocks. Ballasted membranes are not FM Approved, but may be acceptable if installed in accordance with DS 1-29, *Roof Deck Securement and Above-Deck Roof Components*.

Base sheet: The first ply in a BUR or modified bitumen construction if it not applied in a shingled fashion. The base sheet may be adhered or mechanically fastened. Not all BUR's incorporate base sheets.

Batten: A metal or plastic band, usually 1 in. (25 mm) wide, used with fasteners to secure single-ply membranes.

Bitumen: A generic term used to describe asphalt, tar, and pitch.

Built-up roof (BUR) cover: A continuous, semi-flexible roof cover assembly, consisting of plies of felts, fabrics or mats between which alternate layers of asphalt, coat tar or cold adhesive are applied. BURs are generally surfaced with aggregate or a cap sheet.

FM Approved: Products and services that have satisfied the criteria for FM Approval. Refer to the Approval Guide, an online resource of FM Approvals, for a complete listing of products and services that are FM Approved.

Zone 1 design pressures: Design wind uplift pressures for **Zone 1** of the roof determined using DS 1-28 Wind Design or RoofNav. These do not include a safety factor.

Mechanically attached single-ply membrane: The single-ply roof cover is secured to the roof deck with mechanical fasteners. The does not include single-ply membranes that are fully or partially adhered to an insulation or cover board.

Mechanically fastened base sheet: A bituminous base sheet that is mechanically fastened to the roof deck, with one or more layers of bituminous sheet adhered above it.

Re-cover roof constructions over existing FM Approved roof: The new components are installed over the existing roof cover. If more than one existing roof is present, the existing components should be removed (see "Re-roof"). Remove and replace all wet insulation materials prior to application of the new roof system, remove existing gravel and cut out blisters. In all cases, the wind uplift resistance of the completed roof is the lesser of the rating of the recover RoofNav assembly or that of the substrate to which the recover assembly is secured. The addition of a new roof assembly in re-cover construction will not upgrade an existing Class 2 roof assembly to Class 1. The fire rating of the existing steel deck roof is assumed to be Class 2, requiring automatic sprinkler protection under the roof if the original roof assembly is not FM Approved.

Re-roof: Re-roof roof construction requires stripping the existing roof system, consisting of all membranes, insulations (see exceptions for lightweight insulating concrete [LWIC] and steel deck), fasteners, etc., down to the bare substrate (i.e., steel deck, structural concrete, or wood deck). In all cases the existing deck must be sound. The roof system is then installed according to the RoofNav assembly and the applicable Data Sheet. In all cases the wind uplift resistance of the re-roofed assembly is the lesser of the rating of the re-roof assembly or that of the substrate to which the re-roof assembly is secured. When re-roofing over gypsum, cementitious wood fiber or LWIC, verify fastener pull-out performance with field tests per DS 1-29. Refer to DS 1-29 for pull-out tests on other substrates.

Roof cover: The exterior surface of a roof assembly.

Zone 1: Roof area inside Zones 2 and 3 and outside Zone 1' (when present). See DS 1-28 for location and dimensions.

Zone 1': Roof area inward of Zone 1 for relatively wide, (roof width is greater than 2.4 times the building height), low slope (≤ 7 deg.) buildings. See DS 1-28 for location and dimensions.

Zone 2: Roof perimeter area between Zone 3 (corners). See DS 1-28 for location and dimensions.

Zone 3: The roof perimeter area at the corners. See DS 1-28 for location and dimensions.

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).

February 2020. Minor editorial changes were made to reflect the latest version of Data Sheet 1-28. This includes renaming the field, perimeter, and corner roof areas as Zone 1, Zone 2, and Zone 3, respectively, and adding the new Zone 1' roof area. Guidance for Maximum 8 in. (200 mm) screw spacing was added to Table 2.2.2.3-1.

January 2018. This document has been completely revised. The following changes were made:

- A. Changed the title of the data sheet from Repair of Wind-Damaged Roof Systems to Repair of Wind-Damaged Single- and Multi-Ply Roof Systems.
- B. Added new recommendations for fastening damaged roofs.
- C. Deleted Appendix C and moved its information to Section 3.0, Support for Recommendations.
- D. Made editorial and formatting changes.

October 2012. Minor editorial changes were made.

May 2000. This document has been reorganized to provide a consistent format.