HAIL DAMAGE

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1.0 SCOPE

This data sheet provides loss prevention guidelines to aid in minimizing the potential for hail damage to buildings, roof-mounted equipment, and other outdoor equipment.

This data sheet does not apply to photovoltaic panels and ancillary equipment that are roof- or ground-mounted, concentrating solar power systems, or wind turbines. Refer to Data Sheet 1-15, *Roof-Mounted Solar Photovoltaic Panels*; Data Sheet 7-105, *Concentrating Solar Power*; Data Sheet 7-106, *Ground Mounted Solar Photovoltaic Power*; or Data Sheet 13-10, *Wind Turbines*, as applicable.

Follow guidance in Data Sheet 1-28, *Wind Design*, for appropriate wind ratings for roofs and walls, and in Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*, for interior and exterior roof fire ratings.

1.1 Hazards

Hailstorms are a widespread hazard affecting many areas of the world that can severely damage building roofs, rooftop heating, ventilating, and air conditioning units, and skylights. Cooling towers and the exposed glass and plastic components of outdoor equipment can also be damaged, while some of the largest hail losses have been to outdoor storage of vehicles. Providing hail-resistant exterior building components and equipment can greatly reduce this hazard. Damaging hail as shown in Figures 2.1-1 and 2.1-2 does occur outside the very severe and severe hail areas, only with lesser frequency.

1.2 Changes

July 2018. Interim revision. Minor editorial changes were made.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

Hailstorms are widespread, with damaging hail (Figures 2.1-1 and 2.1-2) found in many areas, but with the highest frequency in severe and very severe hail areas.

Fig. 2.1-1. Size comparison of large hail stone to golf ball

Fig. 2.1-2. Size comparison of large hail stone to tennis ball

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 Roof*Nav*, 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 prior to making repairs. A re-inspection 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, including using cold-applied adhesives when repairing base flashings. If torch-applied repairs are made, follow 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 ft^2 (929 m^2). Adhere to the recommendations in DS 1-0, *Safeguards During Construction, Alteration, and Demolition*, and DS 1-33, *Safeguarding Torch-Applied Roof Coverings*.

2.2 Construction and Location

2.2.1 Very Severe Hail (VSH) Hazard Areas

2.2.1.1 Install FM Approved roof assemblies with a VSH hail rating, or a concrete paver ballasted roof following DS 1-29, or an acceptable alternative per Table 2.2.1.1-1.

Use Roof*Nav* to find properly rated roof assemblies.

See Appendix C for the map of the hail hazard areas in the contiguous United States, and Appendix A, Glossary of Terms, for classification of hail hazard areas outside the contiguous United States.

Table 2.2.1.1-1. Recommended Hail Ratings for Roofs

Hail Hazard Area	*Recommended or Acceptable?*	*Roof Assembly Type*	*FM Approval Hail Rating*
VSH	Recommended	Single-Ply & modified bitumen	VSH
		Concrete paver ballasted roofs. (See DS 1-29)[1]	N/A
	Acceptable[2]	Standing seam & lap seam panel roofs	SH
		Asphalt shingle or tile roofs	FM Class 4
		Built-Up Roof (BUR)	SH
SH	Recommended	Any FM Approved roof	VSH, SH, FM Class 3, or FM Class 4
		Concrete paver or stone aggregate ballasted roofs. (See DS 1-29)[1]	N/A
MH	Recommended	Any FM Approved roof	VSH, SH, MH, FM Class 2, FM Class 3,or FM Class 4
		Concrete paver or stone aggregate ballasted roofs. (See DS 1-29)[1]	N/A

[1] Follow Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*, for building height and wind speed limitations for concrete paver and aggregate (stone) ballasted roofs.
[2] Where VSH rated roofs are currently unavailable, the roof assembly types shown can be used as an acceptable alternative.

2.2.1.2 Install FM Approved roofs according to the manufacturer's instructions and follow any manufacturers geographic limitations, which may exclude certain roof membranes in areas with larger hail.

2.2.1.3 Select any FM Approved perimeter flashing system and install it in accordance with Data Sheet 1-49, *Perimeter Flashing*. (FM Approved flashing does not have a hail impact rating.) It is critical that proper cant strips are provided, when required, to support built-up or modified bitumen roof covers at the junction between the roof and parapets, roof dividers, or equipment curbs because unsupported roof covers are especially prone to hail damage.

2.2.1.4 When using wall panels, select FM Approved exterior wall panels listed in the *Approval Guide* for natural hazards exposure (FM 4881). Select panels with a VSH hail rating. Follow DS 1-28, *Wind Design*, to select wind rating(s).

2.2.1.5 Where the local authority having jurisdiction (AHJ, also referred to as the "code official") requires smoke and heat vents, do **all** of the following:

A. Select vents that are FM Approved.

B. Currently (2018) there no FM Approved non-metallic dome vents available with a VSH hail rating. If such vents must be used, select a model with severe (S) hail rating.

C. Follow guidance in Data Sheet 1-10, *Interaction of Sprinklers, Smoke and Heat Vents, and Draft Curtains*.

Alternatively, smoke and heat vents can also be protected with minimum No. 11 gauge (0.1205 in. [3.06 mm]) diameter steel wire mesh with maximum mesh opening size of 0.5 in. by 1.0 in (13 by 25 mm) and supported on a steel framework. Increase the wire size if the shortest span (distance between supporting frame members) exceeds 6 ft (1.83 m).

2.2.1.6 When using skylights, do **both** of the following:

A. Select FM Approved skylights that meet FM 4430.

B. Currently (2018) there are no FM Approved skylights available with a VSH hail rating. Select products that are FM Approved with a severe (SH) hail rating.

Alternatively, skylights can be protected with minimum No. 11 gauge (0.1205 in. [3.06 mm]) diameter steel wire mesh with a maximum mesh opening size of 0.5 by 1.0 in. (13 by 25 mm) supported on a steel framework. Increase the wire size by one gauge if the shortest span (distance between supporting frame members) exceeds 6 ft (1.83 m).

2.2.1.7 Provide hail guards or steel wire mesh over all cooling fins on heating, ventilating, and air conditioning (HVAC) equipment. When wire mesh is used, use minimum No. 11 gauge (0.1205 in. [3.06 mm]) diameter steel wire mesh with a maximum mesh opening size of 0.5 in 1.0 in. (13 by 25 mm) supported on a steel framework. Increase the wire size if the shortest span (distance between supporting frame members) exceeds 6 ft (1.8 m).

2.2.1.8 Provide critical outdoor equipment that is able to withstand hail with an impact energy of 53 ft-lb (72 J). Provide vulnerable equipment with hail screens or guards. When these are not commercially available they can be built using steel wire mesh supported on a steel framework with a maximum mesh opening size of 0.5 by 1.0 in. (13 by 25 mm). Use No. 11 gauge (0.1205 in.) (3.06 mm) wire. Increase wire size if the shortest span (distance between supporting frame members) exceeds 6 ft (1.83 m).

2.2.2 Severe Hail (SH) Hazard Areas

2.2.2.1 Install FM Approved roof assemblies or other assemblies recommended for use in the SH hail area in accordance with Table 2.2.1.1-1.

The option for VSH rated roofs provides additional protection against the larger hail that occurs in the severe hail area and should be considered for high-value or important locations.

Use Roof*Nav* to find properly rated roof assemblies.

See Appendix C for a map of very severe, severe, and moderate hail hazard areas in the contiguous United States, and Appendix A, Glossary of Terms, for definitions of very severe, severe, and moderate hail hazard areas outside the contiguous United States.

2.2.2.2 Install FM Approved roofs according to the manufacturer's instructions and adhere to any geographic limitations, which may exclude certain roof membranes in areas with larger hail.

2.2.2.3 Select any FM Approved perimeter flashing system and install it in accordance with Data Sheet 1-49, *Perimeter Flashing*. (FM Approved flashing does not have a hail impact rating.) It is critical that proper cant strips are provided, when required, to support built-up or modified bitumen roof covers at the junction between the roof and parapets, roof dividers, or equipment curbs because unsupported roof covers are especially prone to hail damage.

2.2.2.4 When using wall panels, select FM Approved exterior wall panels listed in the *Approval Guide* for natural hazards exposure (FM 4881). Select panels with a VSH or SH hail rating. Follow DS 1-28, *Wind Design*, to select the appropriate wind rating(s).

2.2.2.5 Where the local authority having jurisdiction (AHJ, also referred to as the “code official”) requires smoke and heat vents, do **all** of the following:

A. Select vents that are FM Approved.

B. For vents with non-metallic domes, select at least a severe (S) hail rating.

C. Follow guidance in Data Sheet 1-10, *Interaction of Sprinklers, Smoke and Heat Vents, and Draft Curtains*.

Alternatively, smoke and heat vents can be protected with minimum No. 11 gauge (0.1205 in. [3.06 mm]) diameter steel wire mesh with maximum mesh opening size of 0.5 by 1.0 in (13 by 25 mm) supported on a steel framework. Increase the wire size if the shortest span (distance between supporting frame members) exceeds 6 ft (1.83 m).

2.2.2.6 When using skylights, do **both** of the following:

A. Select FM Approved skylights with a severe (SH) hail rating per FM 4430.

B. Follow guidance in Data Sheet 1-28, *Wind Design*, for appropriate wind ratings.

Alternatively, skylights can also be protected with minimum No. 11 gauge (0.1205 in. [3.06 mm]) diameter steel wire mesh with maximum mesh opening size of 0.5 by 1.0 in. (13 by 25 mm) supported on a steel framework. Increase the wire size by one gauge if the shortest span (distance between supporting frame members) exceeds 6 ft (1.83 m).

2.2.2.7 Provide hail guards or steel wire mesh over all cooling fins on heating, ventilating, and air conditioning (HVAC) equipment. When wire mesh is used, use minimum No. 11 gauge (0.1205 in. [3.06 mm]) diameter steel wire mesh with a maximum mesh opening size of 0.5 by 1.0 in. (13 by 25 mm) supported on a steel framework. Increase the wire size if the shortest span (distance between supporting frame members) exceeds 6 ft (1.83 m).

2.2.2.8 Provide critical outdoor equipment that is able to withstand hail with an impact energy of 14 ft-lb (19 J). Provide vulnerable equipment hail screens or guards. When these are not commercially available they can be built using steel wire mesh supported on a steel framework with a maximum mesh opening size of 0.5 by 1.0 in. (13 by 25 mm). Use No. 11 gauge (0.1205 in.) (3.06 mm) wire. Increase wire size if the shortest span (distance between supporting frame members) exceeds 6 ft (1.83 m).

2.2.3 Moderate Hail (MH) Hazard Areas

2.2.3.1 Install FM Approved roof assemblies or other assemblies recommended for use in the MH hail area in accordance with Table 2.2.1.1-1.

Use Roof*Nav* to find properly rated roof assemblies.

See Appendix C for a map of very severe, severe, and moderate hail hazard areas in the contiguous United States, and Appendix A for definitions of very severe, severe, and moderate hail hazard areas outside the contiguous United States.

2.2.3.2 Select any FM Approved perimeter flashing system and install it in accordance with Data Sheet 1-49, *Perimeter Flashing*. (FM Approved flashing does not have a hail impact rating.) It is critical that proper cant strips are provided, when required, to support built-up or modified bitumen roof covers at the junction between the roof and parapets, roof dividers, or equipment curbs because unsupported roof covers are especially prone to hail damage.

2.2.3.3 When using wall panels, select FM Approved exterior wall panels listed in the *Approval Guide* for natural hazards exposure (FM 4881). Select panels with a SH or MH hail rating. Follow DS 1-28, *Wind Design*, to select wind rating(s).

2.2.3.4 Where the local authority having jurisdiction (AHJ, also referred to as the “code official”) requires smoke and heat vents, do **all** of the following:

A. Select vents that are FM Approved.

B. For vents with non-metallic domes, select at least a severe (S) or moderate (M) hail rating.

C. Follow guidance in Data Sheet 1-10, *Interaction of Sprinklers, Smoke and Heat Vents, and Draft Curtains*.

Heat and smoke vents can also be protected with minimum No. 11 gauge (0.1205 in. [3.06 mm]) diameter steel wire mesh with maximum mesh opening size of 0.5 by 1.0 in (13 by 25 mm) supported on a steel framework. Increase the wire size if the shortest span (distance between supporting frame members) exceeds 6 ft (1.83 m).

2.2.3.5 When using skylights, do **both** of the following:

A. Select FM Approved skylights with severe (SH) or moderate (MH) hail rating per FM 4430.

B. Follow guidance in Data Sheet 1-28, *Wind Design*, for appropriate wind ratings.

Alternatively, skylights can be protected with minimum No. 11 gauge (0.1205 in. [3.06 mm]) diameter steel wire mesh with maximum mesh opening size of 0.5 by 1.0 in. (13 by 25 mm) supported on a steel framework. Increase the wire size by one gauge if the shortest span (distance between supporting frame members) exceeds 6 ft (1.83 m).

2.3 Operation and Maintenance

2.3.1 Inspect roofs regularly in accordance with the roofing manufacturer’s guidelines, but at least semi-annually and following storms. Use the Manufacturer’s inspection forms and keep them on file.

2.3.1.1 Have inspections conducted by a qualified person who verifies that the roof surface is watertight without any punctures or cracks, and any insulation appears firm and not water damaged. Have the underside of the roof deck checked for indications of leaks.

2.3.1.2 Include the following inspections as applicable:

A. For built-up and modified bitumen roof covers, verify the original surface coating (e.g., coatings, granules or gravel) is intact and covering all areas. Look for deficiencies such as blisters, deteriorating felts (e.g., scrim is showing), and ″alligatored″ surfaces that are especially prone to hail damage. See Figures 2.3.1.2-1 and 2.3.1.2-2.

B. Inspect single-ply membranes for crazing (very fine cracks in the membrane surface) or signs of stretching at the edges and seams, indicating probable embrittlement. Membranes with either condition are especially prone to hail damage and should be promptly inspected by a registered roof consultant (RRC) as certified by RCI Inc. For PVC roofs, see DS 1-32, *Existing PVC Roofs*, for additional guidance.

C. Inspect liquid-applied roof covers for crazing, cracking, peeling, flaking, or erosion. Areas with these conditions are especially prone to hail damage and should be promptly inspected by an RRC as certified by RCI Inc.

D. Inspect clay, concrete, and slate tile roofs for cracks, spalling, or deterioration.

E. Inspect asphalt shingle roofs for cracks, deterioration, and loss of granules.

F. Engage a registered roof consultant (RRC) certified by RCI, Inc. if there are deficiencies over a large area, which may indicate the roof cover needs to be replaced. This becomes more probable as the roof assembly approaches the end of its warranty period or expected life.

2.3.2 Repair or replace roofs to correct deficiencies found during roof inspections promptly in accordance with the manufacturer’s guidelines, and follow Data Sheet 10-3, *Hot Work Management*, for all hot work.

Follow the manufacturer’s repair procedures and additional guidance given in the NRCA *Repair Manual for Low-Slope Membrane Roof Systems*. Consider the expected remaining life of the roof system.

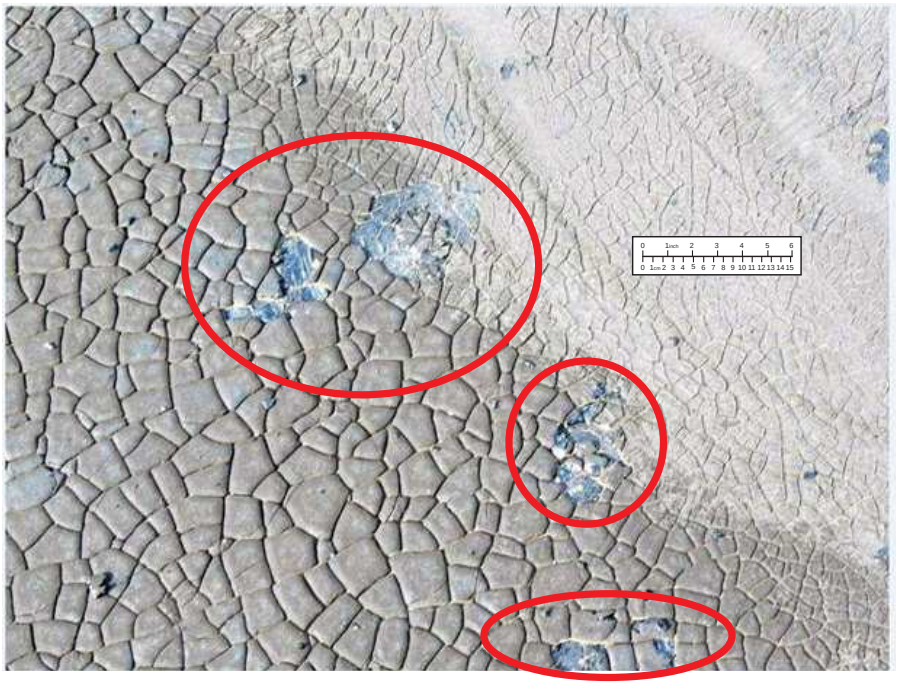

Fig. 2.3.1.2-1. Hail damage to severely 9alligatored9 roof (built-up roof)

Fig. 2.3.1.2-2. Close-up of hail damage to severely 9alligatored9 roof (built-up roof)

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Loss Experience

3.1.1 Cooling fins and condenser coils on heating, ventilating, and air conditioning (HVAC) equipment are extremely susceptible to damage from hail as shown in Figure 3.1.1-1. The majority of this hail damage can be prevented by having hail guards installed over the condenser cooling fins as shown in Figure 3.1.1-2. These are usually available as an option from the HVAC manufacturer, but can also be obtained from other suppliers.

Fig. 3.1.1-1. Hail damaged HVAC unit

Fig. 3.1.1-2. HVAC unit with hail guard over condenser cooling fins at same location as hail damaged unit in Figure 3.1.1-1

3.1.2 Metal roofs are rarely breached by even large hail, and should keep the contents protected and dry, unless they are severely corroded.

3.1.3 Hail often blocks roof drains and gutters, allowing water to enter the building if there isn't a watertight seal between the gutters and the underside of the roof as recommended in DS 1-54.

3.1.4 Acrylic skylights and heat and smoke vents that are embrittled are very susceptible to cracking or puncture from hail. Embrittlement occurs as these items age and can be indicated by discoloration, crazing,

or small cracks. See Figure 3.1.4-1 for holes in acrylic skylights caused by hail, and Figures 3.1.4-2 and 3.1.4-3 for embrittled acrylic skylights. Most acrylic skylights are not impact rated. Some may be double walled.

All FM Approved skylights and glazed heat and smoke vents have polycarbonate or glass glazing.

Fig. 3.1.4-1. Holes in acrylic skylights caused by hail

Fig. 3.1.4-2. Embrittled acrylic skylight

Fig. 3.1.4-3. Close up of embrittled acrylic skylight in Fig. 3.1.4-2

3.1.5 Hail Damage to Outdoor Equipment

Although the majority of outdoor equipment will be undamaged by hail or receive only minor dents to exposed thin metal, equipment with exposed glass or plastic components can be cracked, requiring replacement, and can affect operations.

3.2 Hail Impact Energy

Hail varies greatly in shape and density. For design and test purposes, the impact energy for hail of various sizes is listed in Table 3.2-1.

Hail with a density of 56.2 lb/ft^3 (0.9 g/cm^3) is near solid ice and results in the maximum impact energy expected, while hail with a density of 43.7 lb/ft^3 (0.7 g/cm^3) is the average impact energy.

Table 3.2-1. Impact Energy of Hail for Design Purposes[1]

Hailstone Equivalent Diameter	*Impact Energy*			
	43.7 lb/ft^3 (0.7 g/cm^3) density		56.2 lb/ft^3 (0.9 g/cm^3) density	
in. (mm)	ft-lb	Joules	ft-lb	Joules
1 (25)	1	1.2	1	1.5
1.5 (38)	4	6.0	6	8.6
1.75 (44)	8	11.1	12	16.8
2 (51)	14	19.1	22	29.9
2.5 (64)	35	47.2	58	78.1

[1] Based on terminal velocity at sea level.

3.3 FM Approved Roof Hail Ratings

FM Approved roofs are available with various hail ratings tested to various impact energies. Table 3.3-1 lists the hail ratings and the impact energy each must pass. See the Approval Standards for full test requirements.

Table 3.3-1. Minimum Test Impact Energy for FM Approved Roofs

FM Approved Roof Hail Rating	*Impact Energy, ft-lb (Joules)*
MH / Class 2	8 (11)
SH / Class 3	14 (19)
Class 4	24 (32)
VSH	53 (72)

3.4 Loss History

Hail can damage most exposed surfaces, but the majority of damage is to roofs, followed by damage to cooling fins and condenser coils of rooftop heating, ventilating, and air conditioning equipment, and skylights. There is much less damage to windows, walls, and other equipment. Several of the largest losses have been to outside storage of automobiles. Hail usually impacts all buildings and outside storage at the entire site.

The most easily damaged roofs are asbestos-cement, cementitious fiber, and any roof in poor condition.

Figure 3.4-1 shows an asbestos-cement roof throughout which hail punctured holes, allowing rain water to enter and wet the entire building and machinery, and also contaminate the interior with asbestos. The entire roof needed to be replaced, which, along with asbestos clean-up, affected operations for several months. Although this roof was impacted by 3 in. (76 mm) diameter hail, even small hail can easily puncture such old, brittle roofs.

Figure 3.4-2 shows clay roof tiles that were decimated by hail. Significant water damage can be done to a building interior if there is no solid roof deck with taped seams under clay tiles.

Fig. 3.4-1. Hail damage to asbestos cement roof

Fig. 3.4-2. Hail damage to clay roof tiles

4.0 REFERENCES

4.1 FM Global

Data Sheet 1-10, *Interaction of Sprinklers, Smoke and Heat Vents, and Draft Curtains*
Data Sheet 1-15, *Roof Mounted Solar Photovoltaic Panels*
Data Sheet 1-28, *Wind Design*
Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*
Data Sheet 1-33 *Safeguarding Torch-Applied Roof Coverings*
Data Sheet 1-35, *Green Roofs*
Data Sheet 1-49, *Perimeter Flashing*
Data Sheet 1-54, Roof Loads for New Construction
Data Sheet 7-105, *Concentrating Solar Power*
Data Sheet 7-106, *Ground Mounted Solar Photovoltaic Power*
Data Sheet 13-10, *Wind Turbines*

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

4.2 Other

American National Standards Institute (ANSI). ANSI FM 4473, *Test Standard for Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice balls*. January 2011.

European Standards. EN 13583:2001, *Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing.* Determination of hail resistance. November 2001.

APPENDIX A GLOSSARY OF TERMS

FM Approved: Products and services that have satisfied the criteria for Approval by FM Approvals. Refer to the Approval Guide and/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).

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 Figure C-1.

Registered roof consultant (RRC): A designation made by RCI, Incorporated, which is an international association of professional consultants, architects, and engineers who specialize in the specification and design of roofing, waterproofing, and exterior wall systems. For locations outside the United States where this qualification may not be available, the roof consultant should have completed specialized training or certification from an industry-recognized organization.

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 Figure C-1.

Specification-tested: Products that have been evaluated by FM Approvals according to recognized standards and are subject to examinations and audits by FM Approvals.

Square: A roofing term meaning 100 ft^2 (9.28 m) of roofing area.

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 Figure C-1.

APPENDIX B DOCUMENT REVISION HISTORY

July 2018. Interim revision. Minor editorial changes were made.

March 2018. The following major changes were made for this revision:

A. The contiguous US hail map was revised and uses a 15 year mean recurrence interval.

B. Definitions for very severe, severe, and moderate hail areas outside the contiguous United States were changed.

October 2014. This document was completely rewritten. The following major changes were made:

A. Scope was revised to apply to all locations.

B. Recommendations were added to provide FM Approved hail rated products, and previous recommendations were edited.

C. Very severe hail (VSH) area was added and definitions for severe and moderate hail hazard areas were clarified.

D. Information on hail test standards was added.

E. Loss History, References, and Appendix A were expanded.

September 2009. Hailstorm hazard map was reformatted. No technical changes were made.

January 2009. Minor editorial changes were made for this revision.

May 2008. Appendix B, Document Revision History was updated.

May 2001. Hailstorm hazard map was improved and is now located at the end of the data sheet.

January 2000. This revision of the document has been reorganized to provide a consistent format.

May 1998. Revised.

October 1985. DS 1-47S.1 was replaced with a new DS 1-34.

APPENDIX C CONTIGUOUS UNITED STATES HAIL MAP

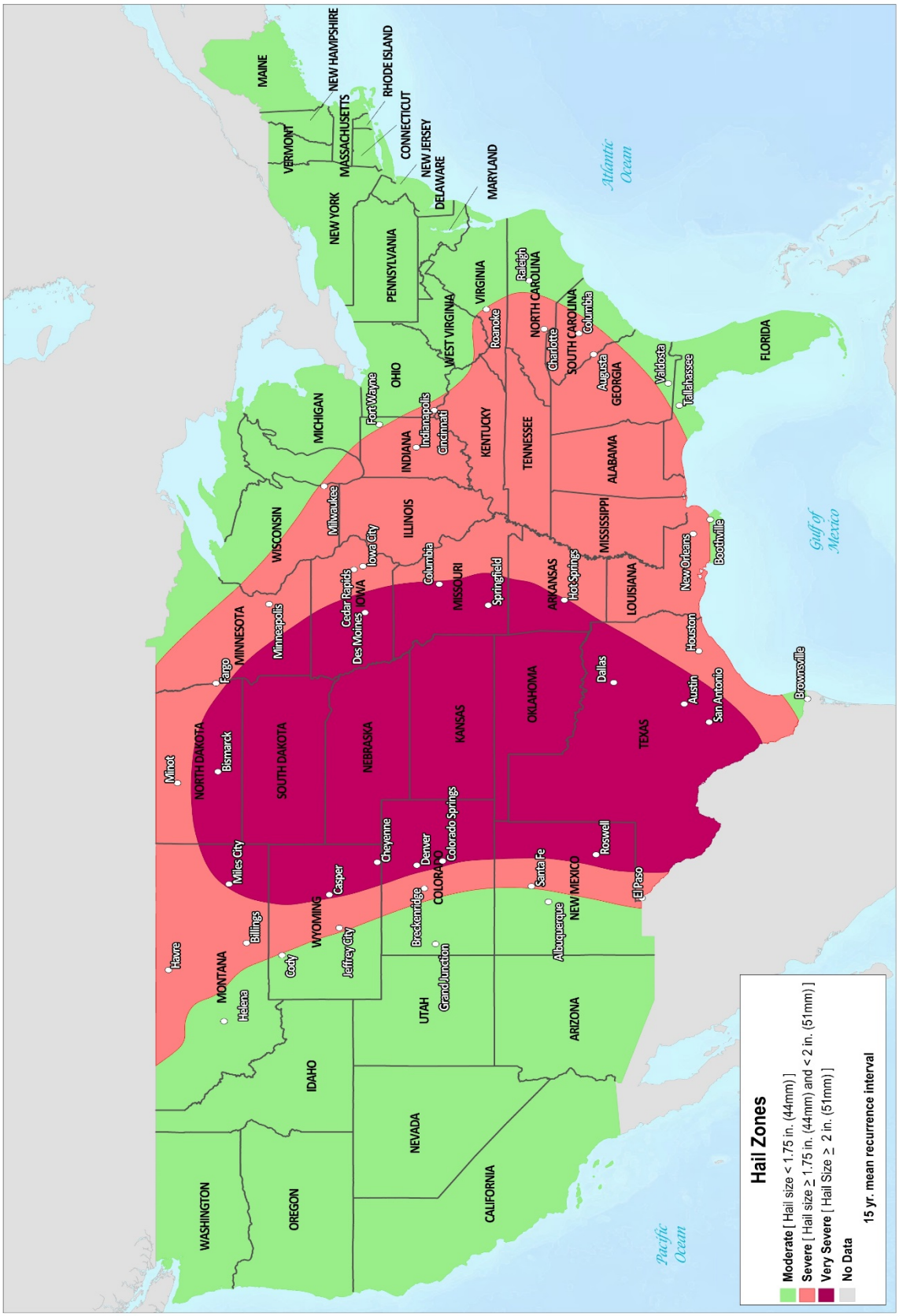

Fig.C-1. Hailstorm hazard map for the contiguous United States (ρ= 0.7g/cm^3)