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 roof- or ground-mounted photovoltaic systems, fabric and membrane structures, concentrating solar power systems, or wind turbines. Refer to Data Sheet 1-15, *Roof-Mounted Solar Photovoltaic Panels*, Data Sheet 1-59, *Fabric and Membrane Structures*, Data Sheet 7-106, *Ground Mounted Solar Photovoltaic Power*; or Data Sheet 13-10, *Land-Based Wind Turbines and Farms*, as applicable.

Follow guidance in Data Sheet 1-28, *Wind Design*, for appropriate wind ratings for roofs and walls, skylights, and heat and smoke vents, 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, but with lower frequency.

1.2 Changes

October 2025. Interim revision. The following changes were made:

A. Deleted references to Data Sheet 1-32, *Inspection and Maintenance of Roof Systems,* that was made obsolete.

B. Deleted specific references to geographic areas.

C. Updated hail report maps in Appendix D.

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

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*.

Fig. 2.1-2. Size comparison between large hail stone and baseball

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 roof assemblies recommended for use in VSH areas in accordance with Table 2.3-1. Follow DS 1-28, *Wind Design*, for wind ratings.

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.

2.2.1.2 Install FM Approved roofs according to the Roof*Nav* listing and the manufacturer's instructions.

2.2.1.3 When using perimeter flashing, 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 exterior wall panels, select FM Approved exterior wall panels with a VSH hail rating. Follow DS 1-28, *Wind Design*, to determine wind ratings. Products can be found in the *Approval Guide* under FM Approval Class 4881.

2.2.1.5 Where the local authority having jurisdiction (AHJ, also referred to as the "code official") requires smoke and heat vents, select FM Approved heat and smoke vents with a VSH rating or FM Approved metallic units. See DS 1-28, *Wind Design*, to determine wind ratings. Also follow guidance in Data Sheet 1-10, *Interaction of Sprinklers*, Smoke and Heat Vents, and Draft Curtains.

2.2.1.6 When using skylights (includes atriums and greenhouses) select FM Approved skylights with a VSH rating. See 2.4 for information on hail guards and DS 1-28, *Wind Design*.

2.2.1.7 Provide hail guards over the condenser cooling fins on heating, ventilating, and air conditioning (HVAC) equipment. See Section 2.4 for information on hail guards.

2.2.1.8 Use critical outdoor equipment that is resistant to hail with an impact energy of 53 ft-lb (72 J) or provide hail guards. See Section 2.4 for information on hail guards.

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 2.3-1. Follow DS 1-28, *Wind Design*, for wind ratings. Consider providing VSH-rated roofs for high-value or important facilities to provide additional protection against the larger hail that occurs in the severe hail area, which can exceed the SH ratings.

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.

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 exterior wall panels, select FM Approved exterior wall panels with VSH or SH hail ratings. Products can be found in the *Approval Guide* under FM Approval Class 4881. Follow Data Sheet 1-28, *Wind Design*, for wind ratings.

2.2.2.5 Where the local authority having jurisdiction (AHJ, also referred to as the "code official") requires smoke and heat vents, select FM Approved heat and smoke vents with a VSH, SH+ or SH rating. See DS 1-28, *Wind Design*, to determine wind ratings and follow guidance in Data Sheet 1-10, *Interaction of Sprinklers, Smoke and Heat Vents, and Draft Curtains*.

2.2.2.6 When using skylights, (includes atriums and greenhouses), select FM Approved skylights with a VSH, SH+ or SH hail rating per FM 4431. Follow DS 1-28, *Wind Design, for wind ratings*.

2.2.2.7 Provide hail guards over all condenser cooling fins on heating, ventilating, and air conditioning (HVAC) equipment. See Section 2.4 for information on hail guards.

2.2.2.8 When provided, install critical outdoor equipment that is resistant to hail with an impact energy of 14 ft-lb (19 J) or provide hail guards. See 2.4 for information on hail guards.

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 2.3-1. Follow Data Sheet 1-28, *Wind Design*, for wind ratings. 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 exterior wall panels, select FM Approved exterior wall panels with SH or MH hail ratings. Products are found in the *Approval Guide* under FM Approval Class 4881. Follow Data Sheet 1-28, *Wind Design*, for wind ratings.

2.2.3.4 Where the local authority having jurisdiction (AHJ, also referred to as the "code official") requires smoke and heat vents, select FM Approved heat and smoke vents with a VSH, SH+, SH, or MH rating. See DS 1-28, *Wind Design*, to determine wind ratings and follow guidance in Data Sheet 1-10, *Interaction of Sprinklers, Smoke and Heat Vents, and Draft Curtains*.

2.2.3.5 When using skylights, (includes atriums and greenhouses) select FM Approved skylights with a VSH, SH+, SH or moderate (MH) hail rating per FM 4431. Follow DS 1-28, *Wind Design*, for wind ratings.

2.3 Hail Ratings for Roof Assemblies

2.3.1 Use Table 2.3-1 in conjunction with the recommendations in Section 2.2 to select a roof for each hail area.

Table 2.3-1. Hail Ratings for Roof Assemblies

Hail Hazard Area	*Roof Assembly Type*	*FM Approval Hail Rating*
VSH	Poured concrete or concrete paver covered roof[1,2]	N/A
	Any FM Approved roof	VSH
SH	Any FM Approved roof	VSH, SH, FM Class 3, or FM Class 4
	Poured concrete, concrete paver, or aggregate (stone) covered roof[1,2]	N/A
MH	Any FM Approved roof	VSH, SH, MH, FM Class 2, FM Class 3, or FM Class 4
	Poured concrete, concrete paver, or aggregate (stone) covered roof[1,2]	N/A

Note 1. Follow Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*, for use and restrictions on concrete pavers and aggregate (stone).
Note 2. Concrete pavers meeting ASTM C1491-18, Standard Specification for Concrete Roof Pavers, or equivalent standard outside the US.

2.4 Hail Guards

2.4.1 When hail guards are recommended, contact the equipment manufacturer for compatible hail guards. Ensure they do not interfere with the equipment's operation. Hail guards are available in several different materials, but maximum openings should be 0.5 by 1.0 in. (13 by 25 mm). They can also be constructed from 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).

2.5 Operation and Maintenance

2.5.1 Inspect and maintain roofs with the recommendations for Operation and Maintenance of roofs in Data Sheet 1-28, *Wind Design.* Repair deficiencies or replace roofs with deficiencies over large areas or nearing the end of their useful life. The average life expectancy of most single-ply and multi-ply roof covers is between 14 and 18 years.

2.5.2 Inspect nonmetallic heat and smoke vents and skylights for cracks, crazing, yellowing or discoloration, increased cloudiness, or other damage or indications of embrittlement due to weathering and aging. Replace as needed.

2.5.3 Inspect hail guards on HVAC equipment for proper condition and securement.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Selecting Roofs Using Table 2.3-1.

3.1.1 When using Table 2.3-1, selecting roofs with higher hail ratings, thicker membranes, and/or harder coverboards (such as gypsum or wood) can reduce roof and interior water damage from many hailstorms.

Figures 3.1.1-1 and 3.1.1-2 show a 0.045 in. (1.1 mm) thick single-ply membrane over polyisocyanurate insulation where the membrane was cut throughout by hail, allowing it too "rain" inside a shopping mall. All interior contents and walls were damaged with stores closed for up to 6 months. Figure 3.1.1-3 shows the adjacent roof, with a single-ply membrane that was reportedly thicker and was not damaged by the hailstorm. The damaged membrane was also reportedly 15 years old, which is its average life expectancy.

In VSH areas, concrete and concrete pavers as shown in Figure 3.1.1-4 can protect roof covers from hail larger than 2.5 in. (64 mm) (when close to being solid ice). These are most practical for new and existing

buildings with structural concrete roof decks, which usually can support the additional ballast weight. (A licensed structural engineer should evaluate the roof's dead load capacity when ballasted roofs are installed on existing buildings.)

New steel deck buildings require additional structural steel to support the weight of concrete pavers, and this must be specified in the earliest design phase. This additional cost can be partially offset by lower roof material (thinner membrane and no cover board) and labor costs. See Data Sheet 1-54 for roof loads and Data Sheet 1-29 for wind uplift requirements for ballasted roofs.

Consider local history of hail larger than that to which the roofs have been tested, building values, and the importance of operations and susceptibility of contents and operations to water damage. See Appendix D for maps of where hail 3 in. (76 mm) and larger has occurred in the United States. Three (3) inch (76 mm) diameter hail that is close to being solid ice has an impact energy of 117.8 ft-lb (159.7 J), which is 2.2 times the 53 ft-lb (76.4J) minimum impact energy that VSH roofs are tested to. See Table 3.7.1-1 and 3.7.2-1 for impact energies for FM Approved roofs, and Table 3.6-1 for impact energies of various diameter hail.

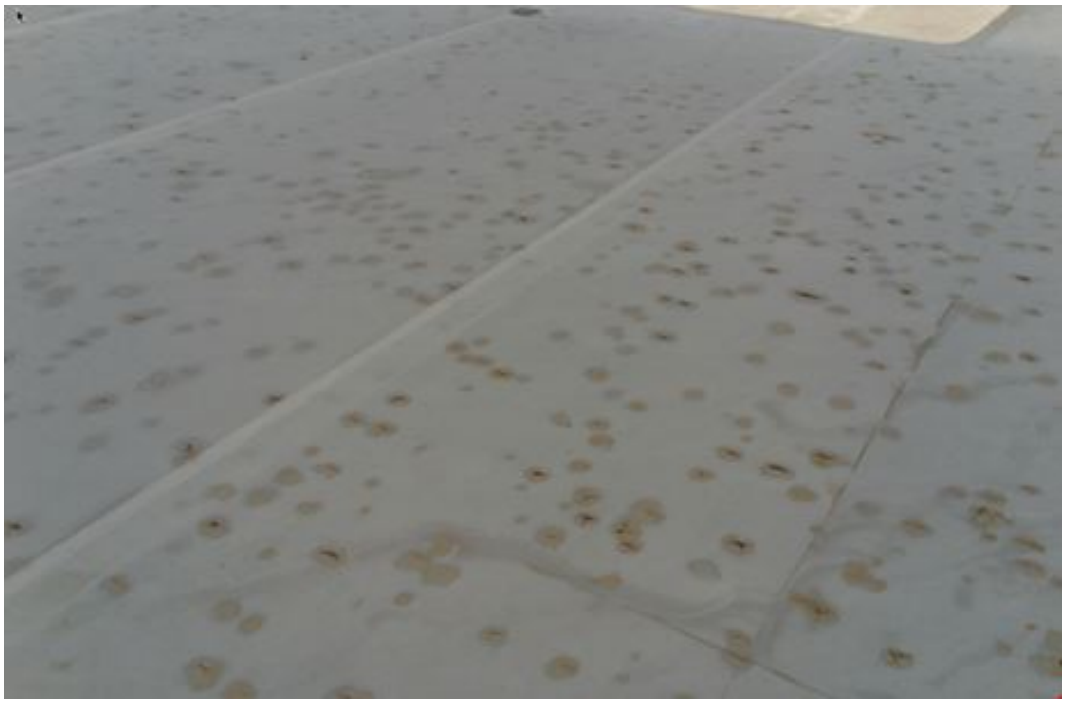

Fig. 3.1.1-1.Single-ply membrane roof 0.045 in. (1.1 mm) thick cut by hail

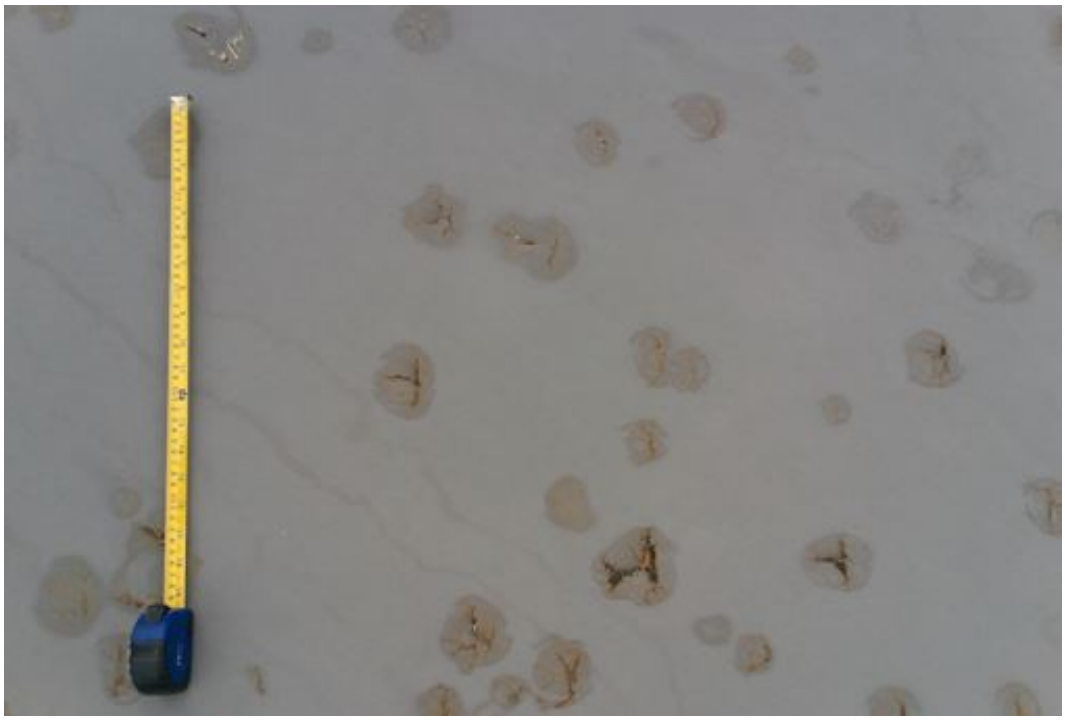

Fig. 3.1.1-2. Close-up of roof in Figure 3.1.1-1

Fig. 3.1.1-3. Undamaged single-ply membrane roof cover adjacent to damaged roof in Figures 3.1.1-1 and 3.1.1-2

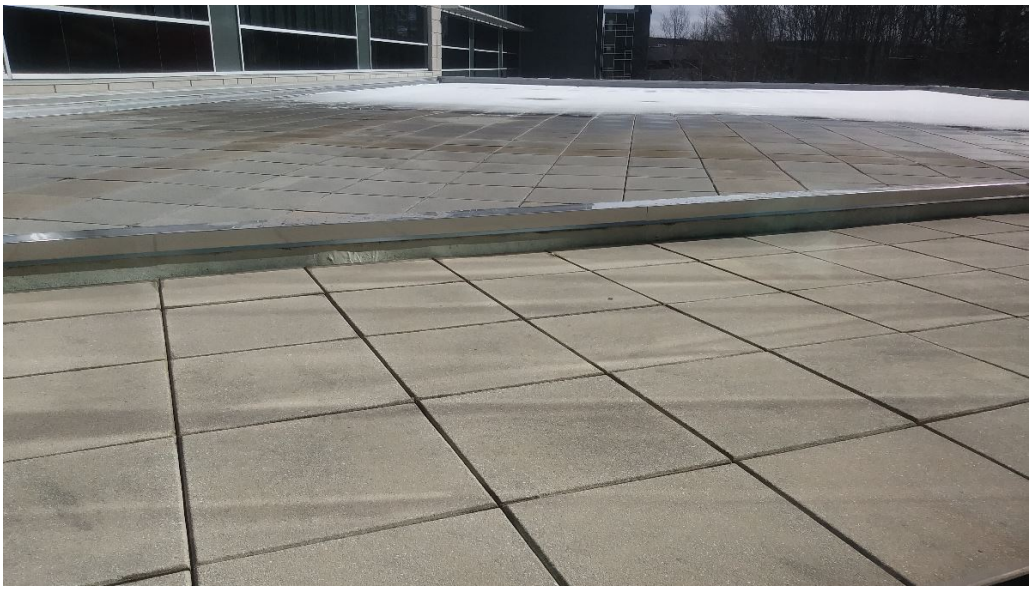

Fig. 3.1.1-4. Concrete paver covered roof

3.2 Skylights

3.2.1 Properly rated and maintained skylights are needed to reduce interior water damage from hailstorms because hail-punctured skylights are one of the main causes of water damage to buildings and contents. There have been many instances in which hail has punctured all the skylights in a warehouse, wetting storage (rain accompanies most hailstorms).

Units that are embrittled are very susceptible to cracking or puncture from small hail. Embrittlement occurs as these age and can be indicated by discoloration, crazing, or small cracks. See Figure 3.2.1-1 for acrylic skylights with holes caused by hail, Figures 3.2.1-2 and 3.2.1-3 for embrittled acrylic skylights, and Figure 3.2.1-4 for a severely weathered greenhouse glass roof panel.

Fig. 3.2.1-1. Holes in acrylic skylights caused by hail

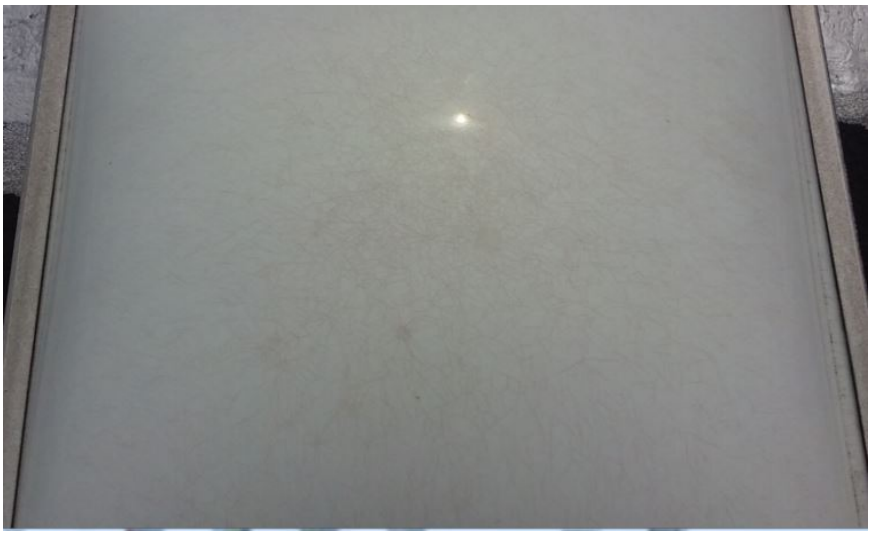

Fig. 3.2.1-2. Embrittled acrylic skylight

Fig. 3.2.1-3. Close up of embrittled acrylic skylight in Fig. 3.2.1-2

Fig. 3.2.1-4. Weathered greenhouse roof glass panel

3.3 HVAC Equipment

3.3.1 Cooling fins and condenser coils on heating, ventilating, and air conditioning (HVAC) equipment are extremely susceptible to damage from small hail as shown in Figure 3.3.1-1. The majority of this hail damage can be prevented by installing hail guards over the condenser cooling fins as shown in Figure 3.3.1-2. These are usually available as an option from the HVAC equipment manufacturer, but can also be obtained from other suppliers.

Fig. 3.3.1-1. Hail damaged HVAC unit

Fig. 3.3.1-2. HVAC unit with hail guard over condenser cooling fins at same location as hail damaged unit in Figure 3.3.1-1

3.4 Outdoor Equipment

3.4.1 Fragile outdoor equipment, such as those with exposed glass or plastic components, can be cracked or penetrated by hail, requiring replacement and possibly affecting operations. Smaller hail can dent exterior insulation on pipes and vessels, although this usually does not affect operations. Figures 3.4.1-1 and 3.4.1-2 show equipment with major damage that required replacement.

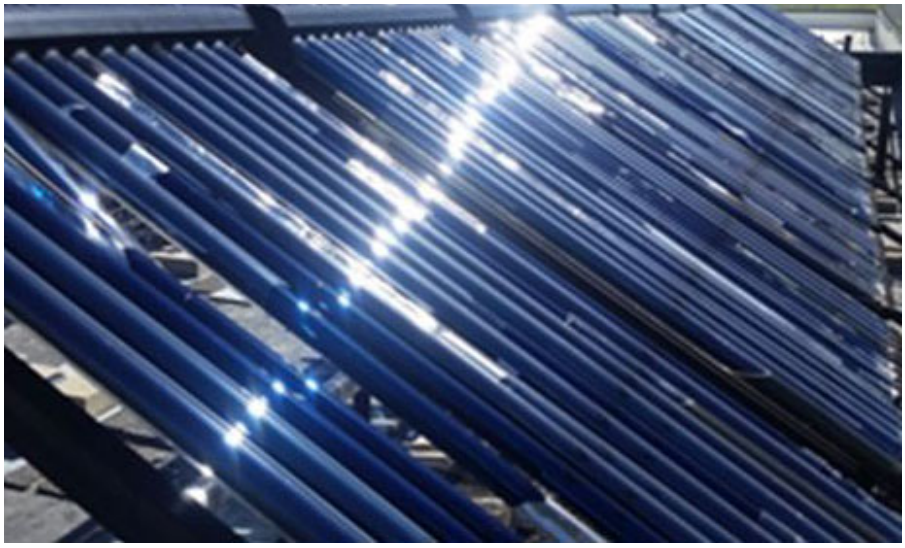

Fig. 3.4.1-1. Glass tube solar heat exchanger damaged by 1.5 in. (38 mm) diameter hail

Fig. 3.4.1-2. Hail damage to plastic drift eliminators

3.5 Operation and Maintenance

3.5.1 Repairing or Replacing Roofs with Visible Deficiencies

Roofs with visible deficiencies such as deterioration, scrim showing, blisters, alligatoring, cracks, or embrittlement are very susceptible to damage from even small hail and should be repaired or replaced.

Figures 3.5.1-1 and 3.5.2-2 show damage from only 1 in. (25 mm) diameter hail to a 20-year old four-ply built-up roof that is “alligatored.” Alligatoring occurs as this type roof ages and solvents in the asphalt leave the roof, resulting in brittleness and loss of adhesion to the fiberglass felts.

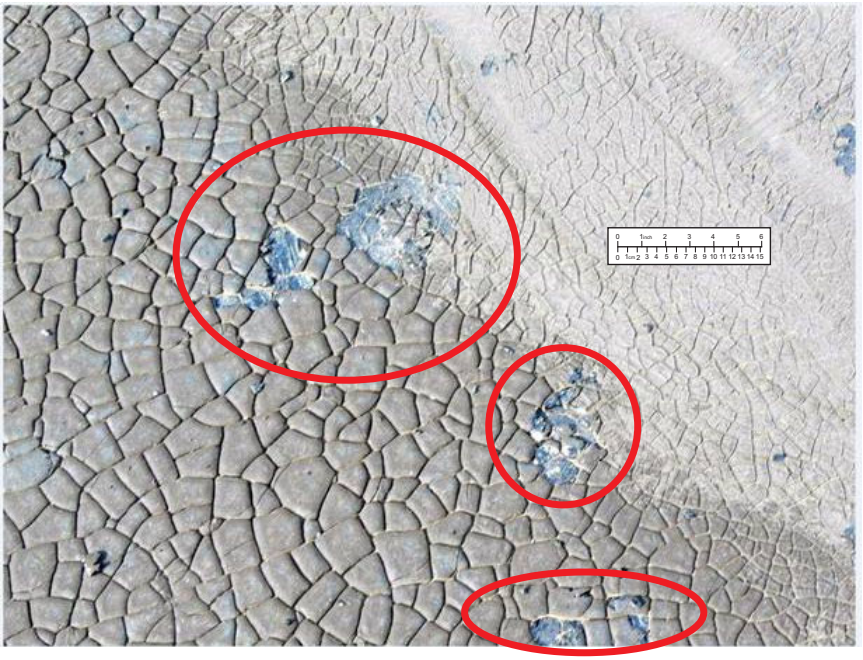

*Fig. 3.5.1-1. Hail damage to severely ″*alligatored*″ roof (built-up roof)*

*Fig. 3.5.1-2. Close-up of hail damage to severely ″*alligatored*″ roof (built-up roof)*

3.5.2 Replacing Older Single and Multi-Ply Roofs

Single and multi-ply roofs have an average life expectancy of 14 to 18 years. This varies considerably based on environmental conditions such as heat, ultraviolet light, moisture and humidity, foot traffic, and wind and hailstorms. There can also be large differences in life expectancy among various manufacturers of the same type of membrane material.

As these roofs age and weather, the roof materials weaken, with many becoming brittle and susceptible to damage from hail smaller than they were Approved to.

This reduction in hail resistance as roofs age can be seen in Figures 3.5.2-1 and 3.5.2.2. This 15-year-old roof was severely fractured by approximately 1.75 in. (44 mm) hail (see Figure 3.5.2-3), allowing rainwater to wet the interior. This size hail should not damage a new FM Approved SH-rated roof and did not damage adjacent roof areas of the same construction that were 10 years old.

Embrittlement was also indicated by the increased flexibility of the unexposed lap section of the roof membrane compared to the weathered roof shown in Figure 3.5.2-4.

Fig. 3.5.2-1. Hail damage to 15-year old single-ply membrane

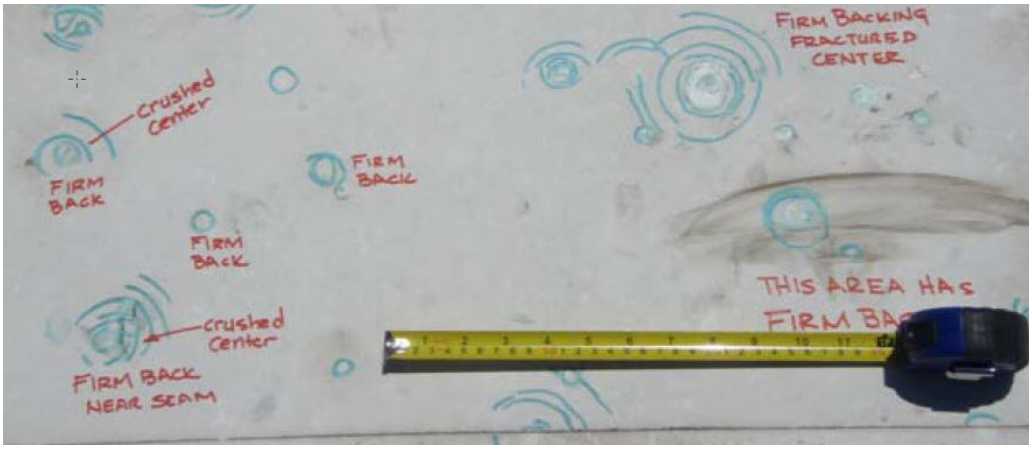

Fig. 3.5.2-2. Close-up of hail damage in Figure 3.5.2-1

Fig. 3.5.2-3. Hail at location in Figures 3.5.2-1 and 3.5.2-2

Fig. 3.5.2-4. Roof cut from hail-damaged roof in Figures 3.5.2-1 and 3.5.2-2

3.6 Hail Impact Energy

Hail varies greatly in shape and density, with the density ranging from a maximum of approximately 56.2 lb/ft^3 (0.9 g/cm^3) when it is mostly solid ice to a low of approximately 25.0 lb/ft^3 (0.4 g/cm^3) when there are more air bubbles entrained. The median density is approximately 43.7 lb/ft^3 (0.7 g/cm^3). Approximate impact energies and terminal velocities for various sizes of spherical hail are in Table 3.6-1.

The largest reported hail stone in the United States was 8 in. (200 mm) diameter and weighed 1.9 lb (0.86 kg). It is pictured, along with a list of the largest hail stones recorded for US states, at https://www.wunderground.com/blog/weatherhistorian/worlds-largest-hailstones.html

Table 3.6-1. Hail Impact Energy and Terminal Velocities[1]

Hail Equivalent Diameter		*Median Hail Density 43.7 lb/ft³ (0.7 g/cm³)*				*Maximum Hail Density 56.2 lb/ft³ (0.9 g/cm³)*			
		Impact Energy		Terminal Velocity		Impact Energy		Terminal Velocity	
in.	mm	ft-lb	Joules	mph	m/s	ft-lb	Joules	mph	m/s
1.00	25	0.8	1.1	44	19	1.4	1.9	49	22
1.25	32	2.1	2.8	49	22	3.4	4.6	56	25
1.50	38	4.3	5.9	54	24	7.2	9.7	61	27
1.75	44	8.1	10.9	58	26	13.3	18.1	66	30
2.00	51	13.8	18.8	63	28	22.9	31.0	71	32
2.25	57	22.3	30.2	66	30	36.8	49.9	75	34
2.50	64	34.1	46.2	70	31	56.4	76.4	80	36
2.75	70	50.1	68.0	74	33	82.9	112.3	84	37
3.00	76	71.2	96.6	77	35	117.8	159.7	88	39
4.00	102	227.7	308.8	90	40	376.5	510.4	102	45

Note 1. Based on terminal velocity at sea level.

3.7 FM Approved Roof Hail Ratings

3.7.1 Hail Ratings for FM Approved Roofs, Class 4470

Roofs FM Approved according to FM Examination Standard 4470 are available with the hail ratings detailed in Table 3.7.1-1.

Table 3.7.1-1 FM Examination Standard 4470 Hail Rating Impact Energy

Hail Rating	*Kinetic Energy, ft-lb (J)*
MH	8 (10.8)
SH	14 (19)
VSH	53-58 (72-79)

3.7.2 Hail Ratings for FM Approved Steep Slope Roof Covers, Class 4475; and Spec-Tested Rigid Roofing Materials, Class 4473

Steep slope roofs are FM Approved according to FM Examination Standard 4475. The hail ratings are based on the kinetic energy values detailed in Table 3.7.2-1. This includes various forms of shingles and tiles made from materials such as slate, concrete, or clay.

Table 3.7.2-1 FM Examination Standard 4475 Hail Rating Impact Energy

Hail Rating	*Nominal Ice Ball Diameter, in. (mm)*	*Target Kinetic Energy, FM 4475, ft-lb (J)*
2	1.5 (38.1)	7.77 (10.4)
3	1.75 (44.5)	14.95 (20.3)
4	2.0 (50.8)	26.81 (36.4)
VSH (4475 only)	2.0 (50.8)	53 (72)

3.7.3 Hail Ratings for FM Approved Heat and Smoke Vents, Class 4430; and FM Approved Skylights, Class 4431.

Non-metallic heat and smoke vents and skylights are FM Approved according to FM Examination Standards 4430/4431. The hail ratings are available are based on the kinetic energy values detailed in Table 3.7.3-1.

Table 3.7.3-1 FM Examination Standard 4430/4431 Hail Rating Impact Energy

Hail Rating	*Nominal Ice Ball Diameter, in. (mm)*	*Kinetic Energy, ft-lbs (J)*
MH	1.5 (38)	7.8-8.6 (10.4-11.6)
SH	1.75 (44)	14.9-16.5 (20.3-22.4)
SH+	2.0 (51)	26.8-29.5 (36.4-40)
VSH	2.0 (51)	53-58 (72-79)

3.7.4 Other Rooftop Components

FM Approved roof perimeter flashing is not tested for hail impact, while FM Approved cooling towers have wall panels and segments of fan stacks tested for large debris impact.

3.8 Loss History

Hail impacts most horizontal surfaces damaging those that are not properly designed for hail impact. Most of the 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 and walls. 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 old corrugated asbestos-cement roofs and any roof in poor condition.

Figure 3.8-1 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 3.8-2 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. 3.8-1. Hail damage to asbestos cement roof

Fig. 3.8-2. Hail damage to clay roof tiles

4.0 REFERENCES

4.1 FM

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, *Vegetative Roof Systems, Occupied Roof Areas and Decks*
Data Sheet 1-49, *Perimeter Flashing*
Data Sheet 1-54, *Roof Loads for New Construction*
Data Sheet 1-59, *Fabric and Membrane Structures*
Data Sheet 7-106, *Ground Mounted Solar Photovoltaic Power*
Data Sheet 13-10, *Land-Based Wind Turbines and Farms*

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.

ASTM International. ASTM C1491-18, *Standard Specification for Concrete Roof Pavers*. 2018.

ASTM International. ASTM G154-05, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure for Non-Metallic Materials*. 2005.

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 Roof*Nav*, online resources of FM Approvals, for a complete listing of products and services that are FM Approved.

Hail size: Maximum diameter of hail.

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 and Australia as "Moderate" in Figures C-1 and C-2.

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 and Australia as "Severe" in Figures C-1and C-2.

Severe Hail Plus (SH+) rating: A hail rating available for skylights and heat and smoke vents in FM Approvals Examination Standard for Skylights and Examination Standard for Heat and Smoke Vents respectively. Acceptable for use in SH and MH hail areas without hail guards. There is no SH+ hail zone.

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

Split slab concrete roof deck: Waterproofing between slabs (used for parking garages, plaza roofs).

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

Very Severe hail hazard 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 and Australia as "Very Severe" in Figures C-1 and C-2.

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).

October 2025. Interim revision. The following changes were made:

A. Deleted references to Data Sheet 1-32, *Inspection and Maintenance of Roof Systems,* that was made obsolete.

B. Deleted specific references to geographic areas.

C. Updated hail report maps in Appendix D.

April 2025. Interim revision. United States and Australia hail maps were updated using the latest hail data.

July 2023. Interim revision. Editorial changes were made to correct references and clarify wording. Additional information was added on FM Approved Roof Hail Ratings (Section 3.7).

January 2023. Interim revision. Minor editorial changes including to the legends on Figures C-1, D-1 and D-2, and added guidance on selecting skylights and heat and smoke vents with VSH and SH+ ratings. VSH and SH+ ratings are now available for skylights and heat and smoke vents per their respective FM Approvals Examination Standard. SH+ is an additional rating that can be used in SH or MH hail areas without hail guards. There is no SH+ hail zone. See Appendix A for details.

July 2022. Interim revision. Minor editorial changes were made.

July 2021. Interim revision. Minor editorial changes were made.

February 2020. Interim revision. Minor editorial changes were made.

April 2019. Interim revision. Added the following recommendations for locations in very severe hail (VSH) areas:

A. Use only FM Approved VSH rated, poured concrete or concrete paver covered roofs.

B. When new skylights are provided, use FM Approved skylights with a SH rating tested using 2 in. (51 mm) diameter ice balls provided with hail guards.

C. When new heat and smoke vents are provided, use only FM Approved metallic heat and smoke vents.

July 2018. Interim revision. Clarification was made to Table 2.2.1.1-1.

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 HAIL MAPS

Refer to Figure C-1 for contiguous United States hail map.

Refer to Figure C-2 for Australia Hail Map.

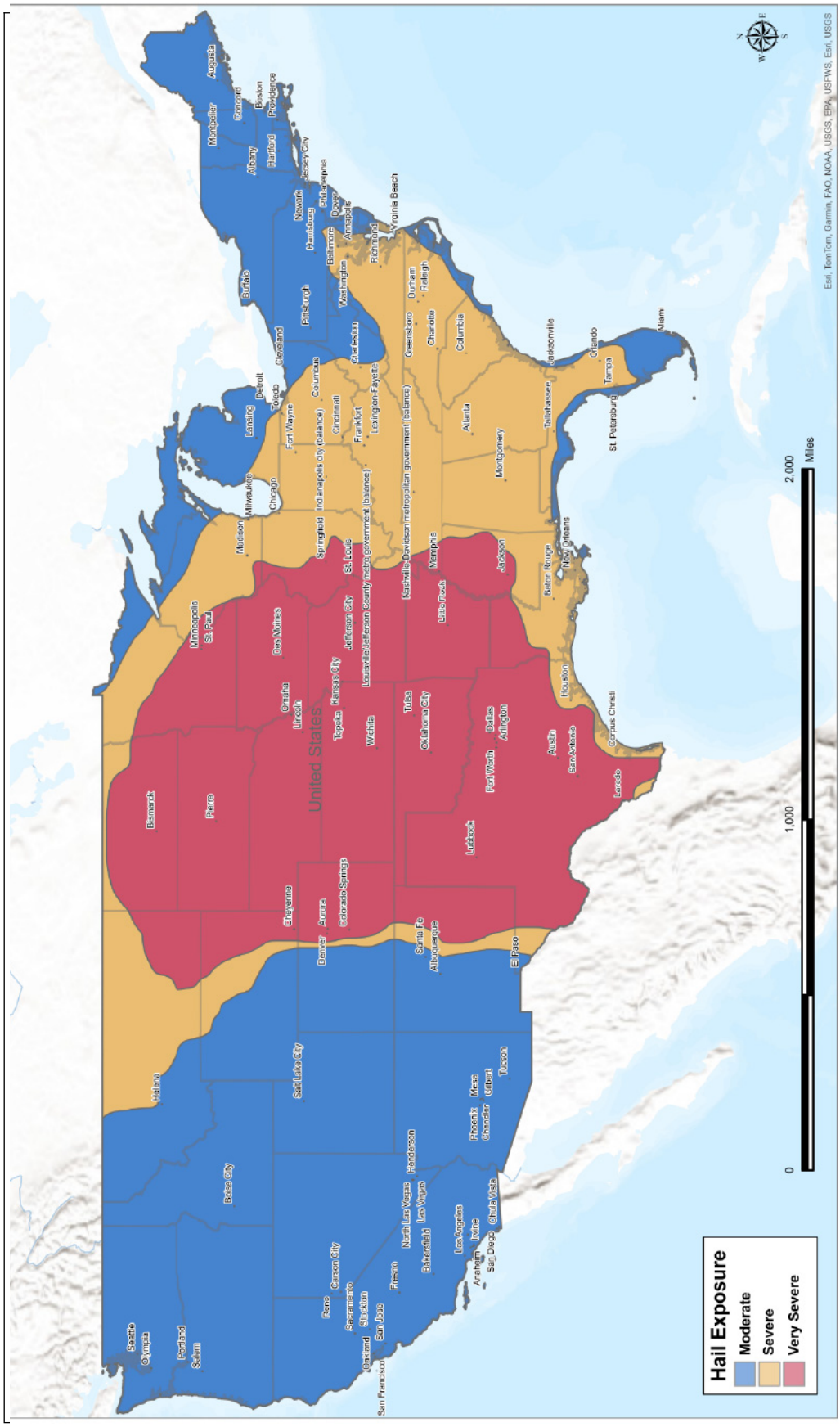

Fig. C-1. Hailstorm hazard map for the contiguous United States (ρ = 0.7 g/cm^3)

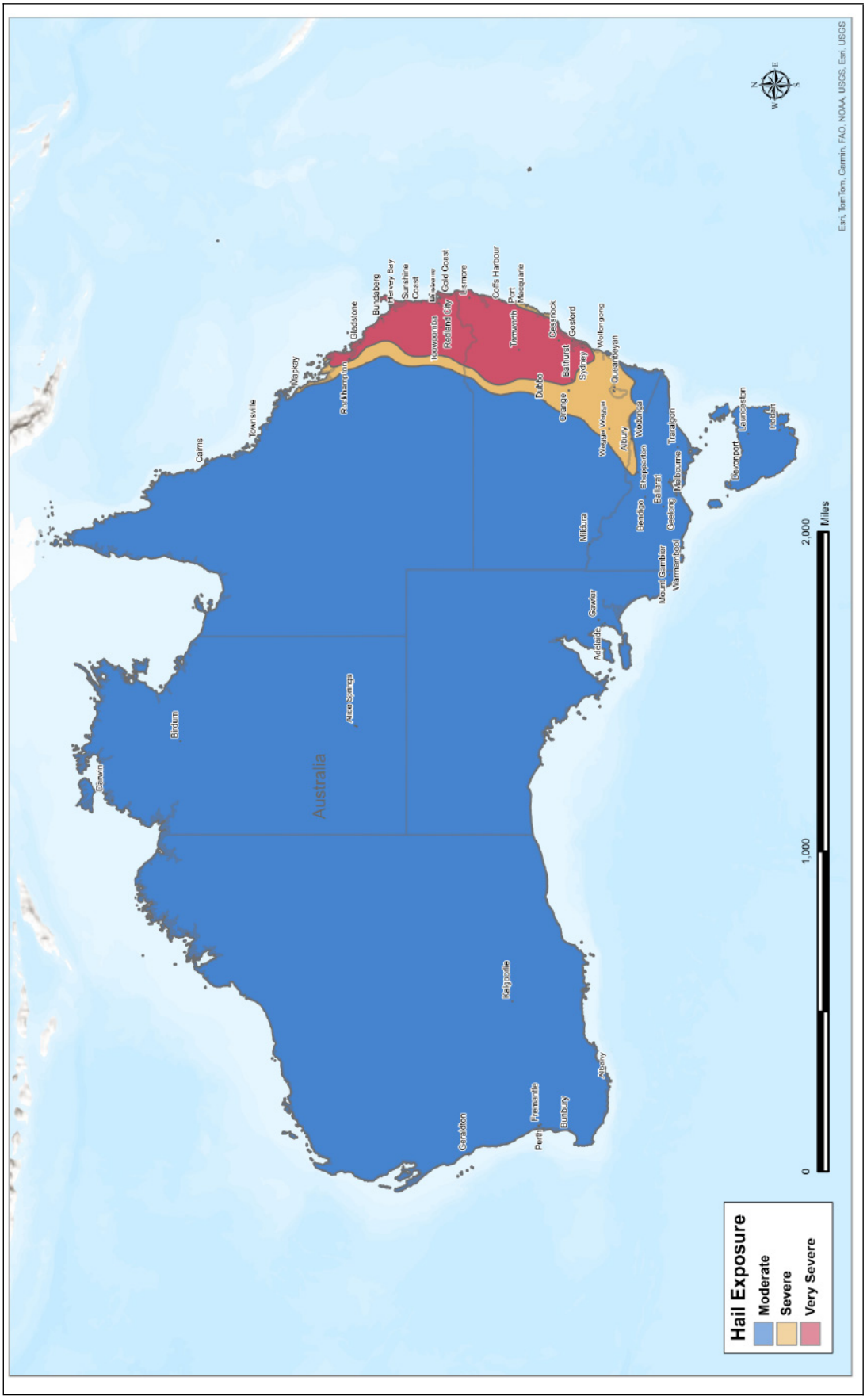

Fig. C-2. Hailstorm hazard map for Australia

APPENDIX D CONTIGUOUS UNITED STATES LARGE HAIL MAPS

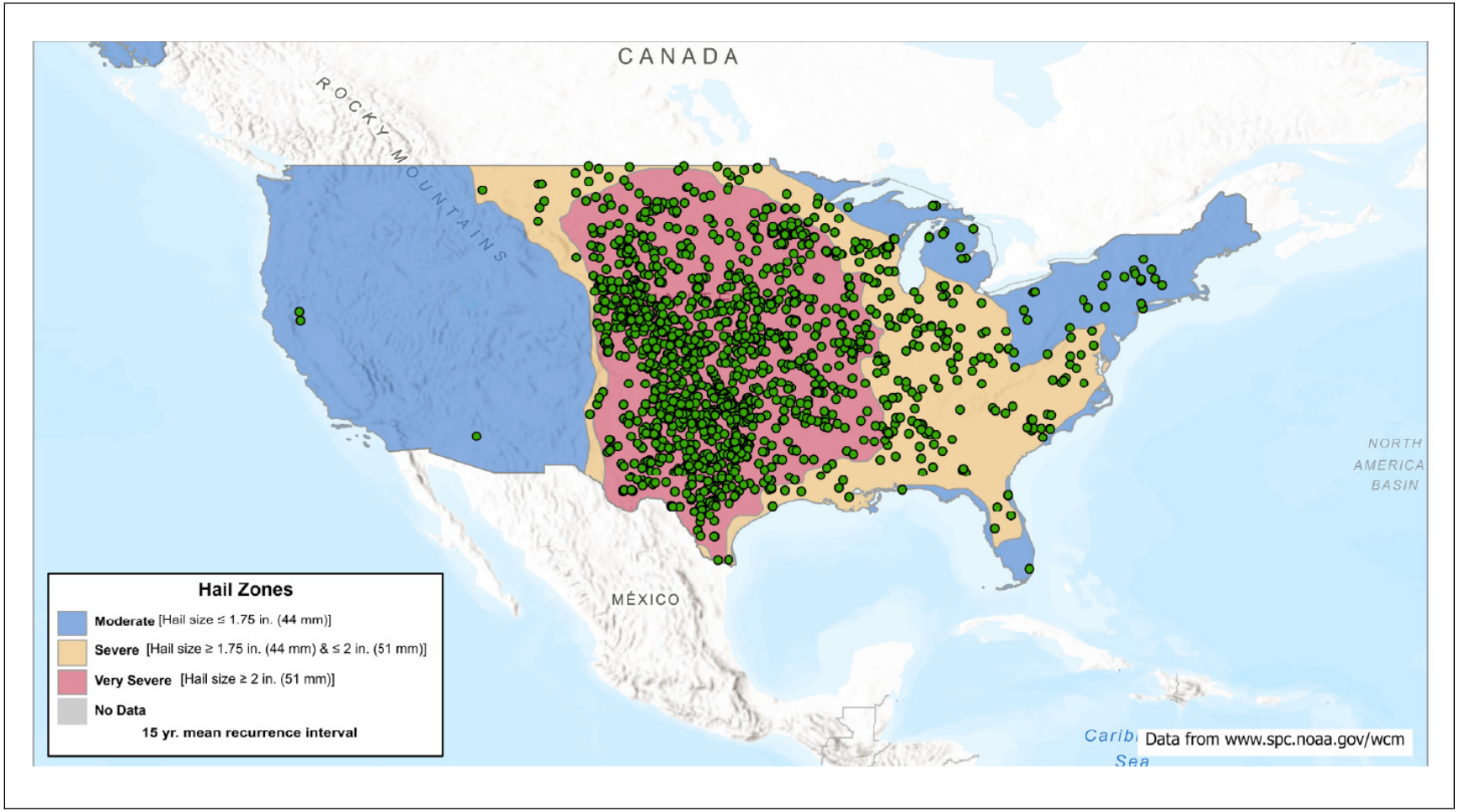

Fig. D-1. Contiguous United States hail reports ≥4 in. (102 mm) diameter (2010-2024)

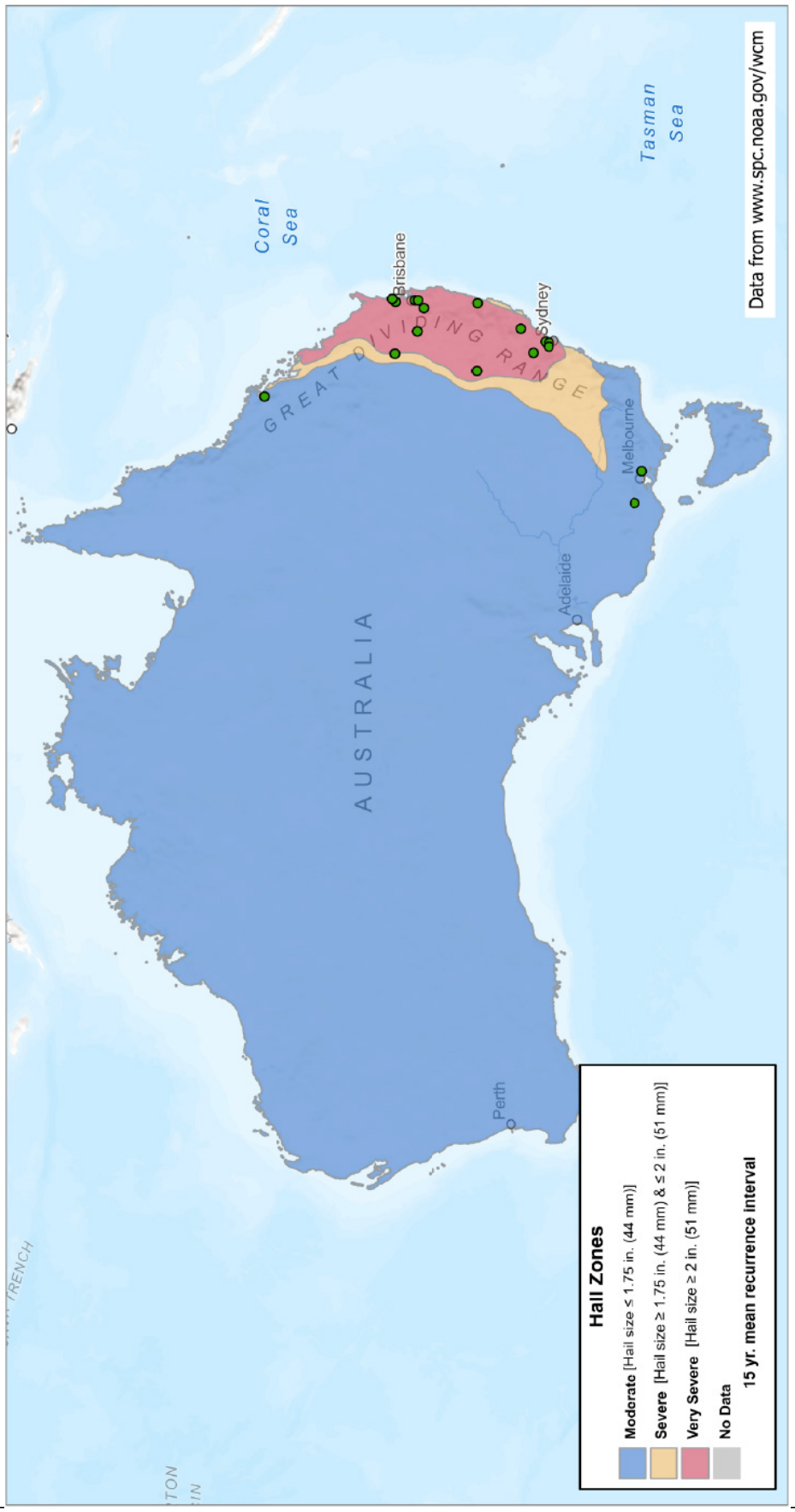

Fig. D-2. Contiguous United States hail reports ≥3 in. (76 mm) and <4 in. (102 mm) diameter (2010-2024)