# Effects of Sub-Severe Hail on Asphalt Shingles

## A Forensic Engineering Position Paper Clarifying Evidentiary Boundaries Between Material Susceptibility, Normal Aging, and Hail-Caused Damage

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## PURPOSE AND SCOPE

This document is a forensic engineering position paper intended to clarify evidentiary boundaries between material susceptibility, normal aging, and hail-caused damage in asphalt composition roofing systems. Its purpose is to evaluate whether recent research regarding sub-severe hail exposure supports conclusions related to physical damage, performance impairment, or roof repair and replacement decisions following a hailstorm.

This paper does not establish new damage criteria, does not propose changes to existing inspection standards, and does not evaluate insurance policy language, claims handling practices, or underwriting methodologies. Rather, it examines whether the methodologies and conclusions presented in recent sub-severe hail research meet the evidentiary requirements necessary for damage attribution and causation in forensic engineering assessments.

The analyses presented herein are limited to demonstrable physical effects, performance, serviceability, and established engineering principles applicable to asphalt shingle roofing systems.

## INTRODUCTION

Asphalt composition roof shingles are the most common roof covering for residential roofs in the United States and cover an estimated 80 percent of all residential roofs [1]. Recent statistics from 2016 through 2018 show there were over 1,650,000 homeowner hail claims in the United States according to the National Insurance Crime Bureau (NICB) [2].

The long-accepted view regarding the minimum threshold size for hail to damage asphalt shingle roofing in midlife or better condition is approximately 1 to 1-1/4 inches in diameter for three-tab and laminated shingles, respectively [3] [4]. Older deteriorated and unsupported asphalt shingles can be bruised (fractured internal reinforcement) by hailstones as small as 3/4 inch in diameter. The National Weather Service (NWS) currently defines severe hail as hailstones that measure one inch in diameter or greater.

Recent research by the Insurance Institute for Business & Home Safety (IBHS) focused on the cumulative effects of sub-severe hail on asphalt shingles. This research was first published in 2023 in a white paper titled “Small Hail, Big Problems, New Approach” [5]. A more comprehensive academic paper based on the same research was published in 2025, titled “Sub-severe hail: the missing piece in assessing asphalt shingle risk in North America [6]. For simplicity, when mentioned together, we will refer to these papers as the “IBHS papers”, and they will be referred to separately as needed by their titles. The IBHS papers state that small hail in high concentrations damage roofs by reducing their underlying resilience. We have concerns that certain concepts discussed in the IBHS papers could be misinterpreted and/or misused by some and research results presented in the IBHS papers do not adequately support some of their expressed opinions.

For the purposes of this paper, the terms hail testing, simulated hail, and ice ball testing are used interchangeably and refer to laboratory impact testing using ice balls propelled onto test specimens to replicate the effects of hail. Laboratory ice ball testing is conducted by controlling the mass and speed of ice ball projectiles to deliver impact energies similar to impact energies delivered by hard hailstones that strike roofing perpendicularly. Laboratory testing of this nature is industry-accepted by roofing manufacturers and insurance companies to develop impact ratings which are used to describe the performance of roofing products and development of insurance premium discounts. Although simulated hail testing does not account for all variables of naturally occurring hailstones, simulated hail testing has been performed for decades and is currently performed as a reasonable analog for development of information regarding the impact resistance of roof coverings from an engineering perspective and forensic evaluations.

Recent publications by IBHS, "Small Hail, Big Problems, New Approach" (2023) and "Sub-severe hail: the missing piece in assessing asphalt shingle risk in North America" (2025), examine the frequency of sub-severe hail events and the potential relevance of sub-severe hail on the future performance of asphalt composition roof shingles. These papers contribute to discussions regarding hail climatology and risk modeling; however, their findings are subject to important limitations when applied to damage assessment.

## EXECUTIVE SUMMARY

Asphalt composition shingles undergo progressive aging due to ultraviolet radiation (UV) exposure, thermal cycling, oxidation, and environmental erosion. These normal weathering processes reduce material resilience over time, which can increase susceptibility to damage from external stressors, including hail impacts. Increased susceptibility, however, is not equivalent to damage. Hail-caused damage requires that impact stresses exceed the strength of the shingle, resulting in rupture or other physical compromise that affect the immediate or long-term water-shedding capability, which is the primary purpose of roof coverings.

The IBHS papers primarily rely on granule loss as an indicator of damage. Granule loss from asphalt shingles is a well-documented, expected process that occurs during transport, installation, early service life, long-term weathering, and foot traffic from roof activities. Asphalt shingles continue to shed water and remain serviceable despite progressive, ongoing granule loss. No threshold was identified by IBHS at which granule loss alone produces failure in terms of watertight performance or quantifiable reduction in expected service life. Without correlating granule loss to breach or time-to-failure, this metric does not support damage determinations or roof replacement decisions.

Additionally, the IBHS testing program did not isolate the effects of sub-severe hail from natural weathering. New shingles were not tested with sub-severe hail alone and weathered-only shingles were not tested with severe hail absent prior sub-severe impacts. As a result, the individual contributions of aging and small hail impacts were not disentangled, and observed changes in granule loss or inferred reductions in resilience cannot be uniquely attributed to sub-severe hail exposure.

The key metric used by IBHS to quantify the effects of sub-severe hail was granule loss measured after impacts by large, two-inch-diameter ice balls. Hailstones of this size routinely rupture asphalt composition shingles, including many impact-resistant products. Once rupture occurs, the controlling damage mechanism is the rupture itself, not granule loss at the impact location. Granule loss measured after known rupture events does not provide meaningful insight into the effects of prior sub-severe hail exposure on shingle performance or service life.

Longstanding field observations and laboratory testing demonstrate that asphalt shingles in mid-life or better condition typically require hailstones on the order of approximately 1 to 1-1/4 inches in diameter to cause rupture, while smaller hailstones may damage only significantly deteriorated and unsupported shingles. The published data do not demonstrate that sub-severe hail produces measurable damage, quantifiable loss of service life, or inevitable future failure of asphalt shingle roofing systems. While sub-severe hail exposure may be relevant for underwriting and risk modeling, it does not support roof repair or replacement decisions in the absence of demonstrable physical damage.

## ACKNOWLEDGMENT OF RESEARCH CONTRIBUTIONS

The IBHS papers contribute meaningfully to the discussion of hail risk by demonstrating that small hailstones dominate hail climatology by frequency. The papers also highlight the role of material aging and weathering on the effects of hailstone impacts, specifically demonstrating that loss of granule surfacing from shingles increases as shingles age (i.e., exposed to natural weathering effects). These efforts can prove valuable in advancing risk modeling and underwriting strategies; however, their efforts are considerably less conclusive when applied to post-storm damage assessment, which requires a higher evidentiary standard.

## TECHNICAL CONSIDERATIONS

It is important to note that naturally occurring hailstones can have less impact energy than ice balls used in testing if hailstones are not frozen solid or if they contain air bubbles. This is because laboratory ice balls are frozen solid and are manufactured to be free of air bubbles, making them denser than most naturally occurring hailstones. Higher density hailstones have more mass than lower density hailstones of the same size, and for this reason, they fall at higher terminal velocities compared to lower density hail. Additionally, hailstones do not impact roof surfaces perpendicularly, unless their fall angle is complimentary with the roof slope angle and their approach is perpendicular to the building. Only then can hailstones strike roof surfaces perpendicularly, and only those roof surfaces that face the oncoming hail. Roof shingles that face other directions or are not sloped complimentary to the hailfall angle will receive glancing hailstone impacts that deliver a fraction of available impact energy to the roof. For the reasons discussed above, it is not uncommon for roof coverings to remain intact, following a hailstorm containing threshold-size hail.

There is a critical distinction between immediate roof damage and the susceptibility of roof coverings to future damage. For example, long-term exposure to weathering can deteriorate the adhesive used to adhere a single-ply roofing membrane to its substrate, reducing its ability to resist future wind events. However, until a wind event occurs that physically displaces the membrane, wind-caused damage has not occurred, even though its underlying resilience has been compromised. Similarly, the long-term effects of high heat, temperature swings, exposure to UV, and rain can thin and embrittle asphalt composition shingles over time. These normal weathering effects can make older shingles more susceptible to bruising by smaller hailstones than when the shingles were first installed. Regardless, the shingles can continue to reliably perform for many years as long as the roof effectively sheds water. In other words, there is a critical distinction to make, which is that susceptibility to future damage is not the same as damage. The IBHS papers, as written, conflate hail damage susceptibility with actual hail damage.

Examples:

“Small Hail, Big Problems, New Approach” includes the following quotes:

> *“Stones less than one-inch in diameter cause accumulated damage to roofs.”*
>
> *“Hailstone impacts, even small ones, cause asphalt shingle roofs to lose resilience and performance.”*
>
> *“Nonetheless, the approach explains how claims can surge after accumulating damage from low severity events.”*

The logic presented in the quotes above progresses from loss of resilience to damage to insurance claims, without a single damaging hail event occurring. This example is missing context because the history of multiple small hail events that occur over several years also involves the exposure of the roof shingles to multiple years of weathering, with or without sub-severe hail events occurring. Furthermore, granule loss is a degradation metric that will occur with or without sub-severe hail, but the paper treats granule loss as a direct damage equivalent. Concurrently, the paper acknowledges the key difference between small and large hail with the following statement.

> *“Impacts from the largest hailstones can cause an immediate threat of water entry, while smaller hailstones do not.”*

The second paper, “Sub-severe hail: the missing piece in assessing asphalt shingle risk in North America”, also conflates loss of granule surfacing with hail-caused damage.

> *“Repeated exposure to these sub-severe events may dislodge enough granules to accelerate shingle deterioration, increasing vulnerability to future hail damage.”*
>
> *“Sub-severe hail—historically excluded from many risk models—can contribute meaningfully to asphalt shingle deterioration.”*
>
> *“This study highlights the damage potential of high concentrations of sub-severe hail.”*

To reiterate the key point discussed previously, long-term weathering also causes loss of granules, which can accelerate shingle deterioration, increasing the vulnerability to future hail damage, even in the absence of sub-severe hail. Figure 1 below shows examples of a new (never installed) asphalt composition shingle and demonstrates exposed asphalt between individual granules. Consequently, coating asphalt on granules is exposed to UV starting the day the shingles are first installed.

It is important to note that the general guideline for the life expectancy of asphalt shingle roofs has been estimated to be about 15 to 30 years [1] [7], which is a much shorter timeframe than modern shingle warranties. Shingle warranty periods should not be conflated with expected service life, but furtherance of that topic is beyond the scope of this discussion.

Figure 1: Surface of a new asphalt shingle under magnification. 10X (left), 18X (center), 40X (right)

## IBHS TESTING

Testing described in the IBHS papers was performed over a two-year period and occurred over three rounds. Testing involved subjecting new control shingles, stored control shingles, and naturally weathered shingles to simulated hailstone impacts. Impact testing included individual large ice balls and a series of impacts using multiple small ice balls (characterized as sub-severe). Large ice balls measured two inches in diameter (50.8 mm) and smaller ice balls measured 0.7 inch (17.8 mm) and 1.0 inch (25.4 mm). Smaller ice balls were a mix of 60 percent 0.7-inch ice balls and 40 percent 1.0-inch ice balls. Ice balls were propelled normal (90°) to shingle surfaces and at impact energies listed in Table 1. The IBHS papers did not state the impact energy of their 2-inch ice ball testing, and instead, stated they performed the testing in accordance with IBHS Impact Resistance Test Protocol for Asphalt Shingles [8], which notes impact energy of 24.0 J (17.7 ft·lbf).

Although one-inch-diameter hail meets the NWS criteria for severe hail, historic literature by Sidney Greenfeld [9] estimated one-inch-diameter hailstones have kinetic energy of less than 1 ft·lbf (1.36 J). Impact testing by Haag follows the same historic, industry accepted hailfall velocities used by Greenfeld; however, target ice ball weights used by Haag assumes maximum density hailstones with a specific gravity of about 0.915, which produces impact energies slightly higher than Greenfeld reported. Kinetic energies used by

Haag for 3/4- and 1-inch diameter ice balls are 0.46 and 1.47 ft·lbf, respectively, or 0.62 and 1.99 J. Comparison to values in Table 1 would indicate most of the smaller ice balls used by IBHS did impact with sub-severe impact energy, even though 40 percent of their ice balls met the severe hail size criteria defined by the NWS.

## TABLE 1: IBHS ICE BALL PARAMETERS

| Ice Ball (in) | Diameter (mm) | Mass (g) | Energy (J) |
|---|---|---|---|
| 0.7 | 17 ± 2% | 2.45 ± 20% | 0.21 to 0.40 |
| 1 | 25.4 ± 2% | 8.45 ± 20% | 0.61 to 2.26 |
| 2 | 50.8 ± 2% | Note [A] | Note [A] |
| Note [A] | Lab-manufactured ice balls using IBHS proprietary system | | |

Table 2 provides a high-level overview of the IBHS testing. Shingles were photographed before and after each round of testing and digital images were processed using a proprietary system and algorithm to determine the amount of granule reduction.

## TABLE 2: IBHS TESTING ROUNDS

| | |
|---|---|
| Pre-testing: | • New shingles tested with 2-inch ice balls. |
| Round 1: | • New shingles stored in controlled environment for one year then tested with combination of 0.7 and 1-inch ice balls.<br>• Shingles weathered outside for one year, then tested with combination of 0.7 and 1-inch ice balls. |
| Round 2: | • Shingles stored for one additional year then tested with combination of 0.7 and 1-inch ice balls.<br>• Shingles weathered outside for one additional year, then tested with combination of 0.7 and 1-inch ice balls. |
| Round 3: | • Stored shingles and weathered shingles impact tested with 2-inch ice balls after Round 2 testing was completed. |
| Analysis: | • Damage multipliers computed based on comparison of granule reduction from pre-testing new shingles, Round 1, and Round 2 testing results. |

The results from the IBHS testing were mostly presented in the context of granule reduction. The only mention of shingle rupture was when describing the IBHS hail impact parameterization system, which incorporates damage severity into a numeric system using an algorithm. The system (as presented) does not assign a numerical rating specifically indicating rupture (breach), but it does indicate that breach is a contributor to the algorithmic rating. Recall from our introduction statement that the minimum size of hail typically able to damage asphalt composition shingles in midlife or better condition is about 1-inch diameter for three-tab shingles and 1-1/4 inches in diameter for laminated shingles. Laboratory impacts made with ice balls measuring two inches in diameter almost always rupture asphalt shingles, including impact-resistant shingles [10]. If an asphalt shingle is bruised by hail, granule loss at the bruise is of little concern because the shingle itself is structurally compromised due to ruptures in the asphalt and reinforcement. In other words, loss of future resilience is no longer an issue when a shingle is bruised.

In summary, IBHS impact tested new shingles, shingles stored in a controlled environment, and naturally weathered shingles with ice balls to simulate the effects of hail. IBHS did not test or pre-test new shingles with sub-severe ice balls and did not test weathered shingles not previously impacted with sub-severe ice balls (weathered-only shingles) with large ice balls. Consequently, IBHS did not establish a baseline for small hail on new shingles, nor did they generate data with large hail on weathered-only shingles.

Naturally weathered shingles are exposed to UV, thermal cycling, oxidative aging, and rain erosion. The lack of impact testing with severe ice balls on weathered-only shingles did not isolate the shingles from these effects. In the presented experiments, weathering and small hail are introduced together, and their individual contributions are not disentangled. Consequently, IBHS' results conflated weathering effects with the effects of sub-severe simulated hailstone impacts. As a result, reported increases in granule loss caused by large ice ball impacts cannot be uniquely attributed to smaller simulated hail testing effects. Their resulting conclusion that small hail materially reduces resilience extends beyond what their test data can independently support.

No service-life threshold was identified by IBHS at which granule loss produces failure. Furthermore, the IBHS papers treated granule loss as a primary indicator of damage, despite the following well-established limitations.

- Granule loss occurs during packaging and transport.
- Granule loss occurs during unpackaging.
- Granule loss occurs during installation.
- Granule loss occurs throughout the shingle service life.
- Granule loss is accelerated during early service life due to loss of hitchhiker granules.
- Granule loss is accelerated late in service life due to cumulative weathering effects.
- Shingles continue to shed water and remain serviceable despite progressive granule loss.
  - » Note, hitchhiker granules are poorly bonded or friction-held (non-bonded) granules on new asphalt shingles that are never fully embedded in the coating asphalt during manufacturing and tend to fall off shingles within a few years of installation.

In addition to the considerations above, which are common to all asphalt shingle roofs, there are other deleterious conditions that commonly arise over the life of an asphalt shingle roof. These can include lichen and other biological growths, bird droppings and other animal activity, heat blisters, excessive foot traffic, manufacturing anomalies, etc.

Without correlating granule reduction to loss of watertight performance, reduction of serviceability, or time-to-failure, arbitrary granule loss metrics cannot support roof replacement decisions. Instead, progressive reductions in granule coverage can be considered to be a modeling variable, but not a predictor of future damage. For example, Haag studied the long-term effects of granule loss decades ago and these results were published in a paper titled "Hail Damage to Asphalt Roof Shingles" [2]. The study involved removing various amounts of granule surfacing from asphalt shingles and naturally weathering the shingle specimens for 10 years. There were two control shingles in the study, including one shingle with no granules removed and one shingle that was weathered upside-down where no granules were present to shield the asphalt from UV or rain erosion. After 10 years of weathering exposure, the only shingle that revealed notable weathering characteristics (beyond fresh black asphalt becoming gray from oxidation) was the upside-down shingle, which exhibited some exposed glass reinforcement fibers. Even after 10 years of weathering, the upside-down shingle continued to shed water.

## FUTURE RESEARCH

Haag, a Salas O'Brien Company, operates an accredited testing laboratory, which is listed as Test Lab 656 (TL-656) by the International Accreditation Service (IAS) [11]. Our laboratory is accredited to perform ANSI/FM 4473 - *Test Standard for Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls*. Our laboratory is exploring future research on asphalt shingles and their response to accelerated weathering and simulated hail impact testing to further explore the effects of degradation caused by UV, high temperature exposure, moisture, and hailstone impacts on the durability of asphalt shingles.

## RECAP

Asphalt composition shingles experience progressive aging due to UV exposure, thermal cycling, oxidation, and environmental erosion. These processes reduce material resilience over time and may cause increased susceptibility to damage from external stressors, including impacts by hail. Hail-caused damage to asphalt shingles remains a result of material stresses at the impact point exceeding the strength of shingle. Long-standing field observations and laboratory testing demonstrate that hard hailstones that impact asphalt roof shingles in midlife or better condition, must exceed about 1 or 1-1/4 inches in diameter to cause ruptures to three-tab or laminated shingles, respectively, while smaller hailstones may rupture only significantly deteriorated and unsupported shingles.

Recent IBHS research has brought attention to the high frequency of sub-severe hail events and their potential role in cumulative material degradation. While these efforts contribute meaningfully to hail climatology and risk modeling discussions, the conclusions presented in the IBHS papers extend beyond what their testing methodology independently supports when applied to hail damage assessment. Specifically, the IBHS research conflated loss of material resilience and granule surfacing with physical damage, despite the fact that granule loss is a well-documented consequence of installation, early service life shedding, and long-term weathering, and does not by itself, indicate loss of watertight performance or service life impairment.

The IBHS testing program did not isolate the effects of sub-severe hail from natural weathering, nor did it establish baseline responses for new shingles subjected only to small hail or for weathered-only shingles subjected to severe hail without prior sub-severe impacts. As a result, the individual contributions of aging and small hail impacts were not disentangled. Consequently, increases in granule loss and inferred reductions in shingle resilience cannot be uniquely attributed to sub-severe hail exposure. Without correlating granule loss to measurable service-life reduction, breach, or time-to-failure, the results are insufficient to support conclusions regarding shingle damage from sub-severe hail or the necessity of roof repair or replacement. Furthermore, the key metric when quantifying the effects of sub-severe hail was granule loss measured after impacts by large, 2-inch-diameter ice balls, which normally rupture asphalt composition shingles. This metric is not meaningful because the primary issue with a ruptured shingle is the rupture, not granule loss at the rupture.

The distinction between susceptibility to future damage and the occurrence of actual damage is critical. Increased vulnerability does not constitute damage, nor does it meet the threshold required to make logical roof repair or roof replacement determinations. While sub-severe hail exposure may be a relevant variable in underwriting models and territory-level risk assessment, it does not justify redefining normal weathering effects as hail damage based on current evidence.

In conclusion, the available data do not demonstrate that small hail produces measurable damage, quantifiable loss of service life, or inevitable failure of asphalt shingle roofing systems. Application of sub-severe hail research should remain confined to appropriate modeling and underwriting contexts. Careful restraint is required to prevent susceptibility modeling from being misinterpreted or misapplied as evidence of damage, thereby preserving established engineering principles.

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