MAY 2020





Technical Bulletin #7 **NATIONAL SLATE ASSOCIATION**

Slate Roof Condition Assessment Surveys

Introduction

Peak U.S. domestic slate roofing production occurred in the years surrounding the turn of the twentieth century, from about 1885 to 1925 (see *Technical Bulletin No.* 5, "Historic Production Data"). Much of this slate is now nearing the end of its expected service life. This *Technical Bulletin* addresses key aspects of assessing the condition of existing slate roofs, with a focus on what to look for with regard to the slate itself, slating nails, and flashings. The condition of roof underlayments for slate roofs will be explored as well.¹

Assessing the Condition of the Slate Shingles

In assessing the condition of slate shingles, it is helpful to have knowledge of the type of slate present on the roof² and the date the shingles were installed. This information, combined with knowledge of the estimated service life of the slate, can provide an insight into the expected remaining service life of the roof. Be aware, this is just an initial insight, which must be tempered by a complete look at the condition of the slate, slating nails, and flashings as outlined below.

The estimated service life of slate shingles depends on the geology of the slate - its mineral composition and the heat

and pressure it was subjected to during its formation - a process known as metamorphosis. Based on past history, it is known that different roofing slates have different estimated service lives depending on which region of the country from which they derive (Figure 1) and assuming all other things associated with the roof are equal. These estimated service lives are shown in Table 1³. Of course, all other things are never equal, and such factors as roof slope and orientation, the presence of shade trees, runoff from low-slope roof areas located above the slate, foot traffic, the quality of the original installation, and maintenance activities, all impact the longevity of the roof system.

As an example, if the roof is covered with Vermont unfading green slate installed in 1925, and the current year is 2020, that means the slate is 95 years old and could have an expected remaining service life of approximately 30 years, depending on the factors discussed previously and the findings of an on-site condition assessment. If the roof slope is found to be only 6:12, and the slate not very well maintained, the roof could be nearing the end of its service life. If, on the other hand, the slope is 14:12 and the roof was installed well to begin with and regularly maintained over the years, it could have an expected remaining service life of 40 years.



MAY 2020



TABLE 1

SLATE DISTRICT	ESTIMATED SERVICE LIFE
Monson (Piscataquis County, Maine)	150 years +/-
New York/Vermont (Washington County, NY/Rutland County, VT)	125 years +/-
Pennsylvania Soft-Vein (aka Pennsylvania Black; Lehigh and Northampton Counties, PA)	60 years or more
Pennsylvania Hard-Vein (aka Chapman; Northampton County, PA)	100 years +/-
Peach Bottom (York County, PA /Harford County, MD)	At least 200 years
Buckingham (Buckingham and Fluvanna Counties, VA)	175 years or more
North Country Black (Saint-Marc-du-Lac-Long, Quebec, Canada)	100 years +/-

2 | NATIONAL SLATE ASSOCIATION TECHNICAL BULLETIN #7



MAY 2020

During the field survey portion of the condition assessment, broken and missing slate shingles can generally be seen from afar - from grade using the naked eye and/or binoculars. It is important to observe the slate upclose as well, to look for such things as cracked slates, exposed nails within the bond lines of the slates (Figure 2), wear holes caused by the heads of the slating nails working their way through overlying slates (Figure 3), and delamination.

Figure 2: Exposed copper slating nail within a bond line; in this case the result of the use of a narrow slate and insufficient offset.





Figure 3: Cracked and broken slates, as well as holes caused by under-driven slating nails working their way through overlying shingles in this c.1966 Pennsylvania Black slate roof.



MAY 2020

Delamination occurs when impurities contained within the slate (primarily calcite and iron sulfides, such as pyrite and marcasite) react, in association with hot/cold and wet/dry cycling, to form calcium sulfate (gypsum) molecules that take up slightly more volume than the original minerals.5 This gradually pushes the slate apart along its cleavage planes, eventually manifesting itself as the paper-thin laminae we observe on the exposed and hidden faces of the slate (Figure 4). As the slate delaminates, it becomes softer and more prone to breakage. It also tends to hold moisture longer, thus becoming susceptible to freeze/ thaw damage. The moisture retained in the slate can also begin to cause the wood roof deck to rot, especially if the original felt underlayment is in poor condition. The lower the slope of the roof, the greater the rate of weathering and deterioration as the slates tend to stay wet for a longer period of time after each precipitation event.

In addition to observing the exposed portion of the slate shingles, a random sampling of slates should be removed in order to observe the back sides of the shingles and allow for sounding the slates. While the slates are out, headlap can be verified, and the type and condition of roof underlayment(s) and slating nails can be observed as well (Figure 5). Removing one to two slates per slope is generally sufficient to draw conclusions, although on a large roof, or particularly large roof area (e.g., on the order of 3,000 to 5,000 square feet), removal of additional slates may be necessary. Removed slates should be reinstalled upon completion of observations.



Figure 4: Severely delaminated slate shingles. The relatively low slope of the roof (5:12) helped to accelerate the rate of deterioration.



Figure 5: Test opening in a 90-year old roof with a slope of 14:12 and covered with slate shingles from the Monson District, Piscataquis County, Maine. The slate, hot-dipped galvanized slating nails, and felt underlayment were found to be in good condition.



MAY 2020

It is important to observe the back side of the slate shingles because it will sometimes be found to be in "worse" condition - that is exhibiting a greater degree of delamination - than the exposed portion (Figure 6).

Sounding a slate is an excellent method by which to gauge its integrity and confirm one's visual observations. The method is simple: grasp the slate in one hand and then tap the exposed face with a knuckle or metal object, such as a slating hammer. Sound slates will emit a distinctive ring when tapped in such a manner. A dull thud, similar to that which might be emitted by a piece of wood, is usually indicative of a very weathered slate that is delaminating. A rattling sound typically indicates a cracked slate, or a slate containing a loose fragment separated from the main body of the shingle along its cleavage plane.

The presence of oxidizable iron pyrites in slate shingles can cause rust staining on the surface of adjacent slates and appear unsightly. The condition, sometimes called "rusting-out," occurs most often in New York/Vermont weathering green slate, but sometimes in unfading green as well. The condition is typically isolated to a relatively few slates. When in an advanced state, the affected area can be flakey and soft due to the increased volume of the oxidation product compared to that of the original pyrite (Figure 7). Replacement of the slate is required to prevent further deterioration and staining.



Figure 6: The exposed portion of this slate (left) exhibits little to no delamination. The unexposed face (right) exhibits a good deal of delamination, especially around the nail holes, where the loss of section is significant.



Figure 7: Oxidized iron pyrite in an isolated New York/Vermont Unfading Green slate on a dormer cheek wall



MAY 2020

As a general rule of thumb based on past experience, if 20-percent or more of the slate shingles on a roof are broken, cracked, missing, sliding out of position, severely delaminated, or suffering from inappropriate past repairs (e.g., face nailed, undersized), then it is often more practical and cost effective to replace the roof than to attempt individual repairs (Figures 8 and 9). This assumes that the deteriorated slates are randomly located, rather than being concentrated in one or two locations.



Figure 8: Sometimes it is necessary to count slates to determine the percentage of broken or otherwise deteriorated shingles present on a roof. Here, roughly 72 of the 369 slates captured in this photograph (19.5%) are in need of repair.



Figure 9: Widespread severe delamination in these 120-year-old **New York/Vermont** unfading green slates, combined with broken, cracked, and missing slates, face-nailed and undersized slates stemming from inappropriate repair work, slates sliding out of position, and the corroding terne metal open valley, makes roof replacement a straightforward decision in this case.

6 | NATIONAL SLATE ASSOCIATION TECHNICAL BULLETIN #7



MAY 2020

Assessing the Condition of the Slating Nails

Various types of nails have been used to secure slate shingles over the years. Copper and stainless steel slating nails will typically be found to be in good condition (Figure 10). Steel/iron cut nails and steel wire nails, and the electroplated versions of these, with only a minimal zinc coating, will often be found to be in poor condition with either their heads corroded off (Figure 11) or that portion of the shank located just above the roof deck corroded nearly through. A common manifestation of corroded fasteners is individual slate shingles sliding out of position (Figure 12).

It should be verified whether fastener corrosion is widespread or localized in areas subject to concentrated water flows, such as below dormer valleys or below where a low-slope roof drains onto the slate roof. If the condition is typical and widespread, it is likely time to replace the roof, lest more shingles continue to slide down-slope, or the shingles become subject to blow-off in high winds. If the corrosion is localized, removal and reinstallation of the slates may be possible.

Figure 12: As a result of the corroded nails shown in Figure 11, numerous slates on this Peach Bottom slate roof had slid out of position.



Figure 10: Ninety-year old copper wire slating nail (left) and 120-year old bronze cut nail (right), both in good condition.

Figure 11: Corroded steel cut nails on a 145-year old slate roof.







MAY 2020

With longer-lived slates such as Peach Bottom and Buckingham, it is possible for the nails to have failed due to poor selection, while the slate shingles themselves still have decades of service life remaining. In such cases, salvage and reinstallation of the slate shingles can be considered. If this course of action is selected, the slate should be re-laid using the same, or less, exposure as the existing to mitigate the visual impact of ghost lines, indicating the original exposure of the slate, on the reinstalled roof (Figure 13).⁶ Keep in mind that exposure and headlap are inversely related and that the change in headlap will always be two times the change in exposure. Increasing headlap beyond that required is acceptable (within limits, of course), whereas reducing headlap is not (see Figure 13).

Assessing the Condition of Flashings

A full discussion of flashing assessment is beyond the scope of this Technical Bulletin.7 Suffice it to say that most slate roofs, should they leak, tend to do so not in the field of the roof, but rather around their edges, at roof penetrations, and at changes in plane - instances in which flashings are (or should be) present. Flashings are critical to the integrity and weathertightness of all roofs, including slate roofs. Those most susceptible to wear occur at areas of concentrated water flows valley flashings, both open and closed, followed by gutters, and base flashings (sometimes called step flashings). The condition of flashings can be observed by pushing the butt ends of the slate shingles slightly to one side (e.g., at the centerline of a closed valley; Figure 14), or by removing slates located atop flashings (Figure 15).



Figure 13: Example of ghost lines on the exposed face of slates that have been reinstalled above a new standing seam copper roof. In the case of partial removal, salvage, and reinstallation of slate shingles it is also important to match the original exposure of the slate in order to maintain the intended headlap. In this case, the extra 1/2" of exposure resulted in the loss of a full inch of headlap; from a 3" headlap down to a 2" headlap. Two-inch headlap is insufficient for the 9:12 slope of the roof. Note too, the lack of patina formation in that portion of the copper roofing located along the drip line of the slate shingles.



Figure 14: Despite the presence of debris, wear holes are still quite evident along the centerline of these 65-yearold copper closed valley flashings. Figure 15: A slate shingle was removed in order to get a better look at the condition of the base flashings located along this gable end wall.



MAY 2020

In areas of concentrated water flows, copper flashings often turn a golden orange color before they actually wear through (Figure 16). This color is an indication that the copper is paper thin (to the point where one can easily push a finger through the material) and in need of replacement. This condition must be distinguished from the duller copper color that indicates a patina is not being formed due to frequent, often concentrated, water flows, but where the copper still has sufficient thickness, as can be seen below the drip line of the slates in Figure 13. Other conditions to look for include

punctures, cracked soldered seams, fatigue cracking, pitting/pin holes along the edges of soldered seams (Figure 17), exposed fasteners, and base flashings that are not consistently spaced,⁸ are too short, or not well counterflashed (Figure 18). The list of possible counterflashing issues is quite long and includes:

- Insufficient lap of one counterflashing over an adjacent counterflashing
- Reglets that are too shallow
- Inadequate spacing of lead wedges to secure the counterflashings in place, or lead wedges placed too close to the outside face of the reglet

- Failed sealant or mortar in the counterflashing reglet
- Counterflashings that are too short to adequately cover the underlying base flashings (see Figure 18)
- Torn, bent, displaced, loose, and missing counterflashings
- Counterflashings that are set too close to the roof surface or stepped incorrectly, thereby limiting the height of the underlying base flashings (see Figure 18)
- Counterflashings secured with exposed fasteners, especially when those fasteners also penetrate the base flashings



Figure 16: Painted copper open valley flashing. The golden orange color indicates that the copper is paper thin. Arrows point to where the copper has already worn through.





Figure 17: Corrosion holes along a soldered seam in a copper flashing.





MAY 2020

Figure 18: On the left, base flashings, which are interwoven with each course of slate, are consistently spaced, but counterflashings are too short and do not provide sufficient cover over the base flashings. On the right, base flashings, although concealed, are known to be too short due to inappropriate layout of the stepped counterflashings. Extending the counterflashings to the right would have allowed for a full 4" vertical leg in the base flashings instead of the 1-3/4" to 2" that was achieved (see double-arrowed line).



Whether or not the poor condition of a roof's flashings merits replacement of the entire roof requires professional judgment and is dependent on several factors. If, for example, the slate and slating nails are in good condition and have an expected remaining service life of 20 or more years, and the roof plan is fairly straightforward (i.e., few changes in plane and a limited number of dormers, chimneys, and skylights all things that require flashings), then a flashing replacement project may be most practical. If the slate only has an expected remaining service life of ten years, and/or the roof is "cut up" (i.e., containing many valleys, dormers, chimneys, and penetrations), it may be that by the time enough slate is removed to replace all of the deteriorated flashings it is simply more practical to replace the entire roof (Figure 19).



Figure 19: The slating nails on this roof were found to be in good condition and the slate possessing a remaining service life of several decades. All flashings and gutters, however, were deteriorated. Given the quantity of slate that would have to be removed to replace all the flashings and gutters, the owner decided to replace the slate as well.

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MAY 2020

Underlayment Condition

One hundred-year old asphalt-saturated organic felt underlayments often lack integrity, or have nearly turned to dust, crumbling or breaking apart when handled. The question often arises: When does the poor condition of underlayment require that the slate roof be replaced? Every roof is different, so the answer is, it depends. Here are a few typical scenarios that can be used as a guide:

- The underlayment is in poor condition, but the slates, slating nails, and flashings are in good condition and the roof does not leak, even in the worst wind-blown rains: This is a good indication that the roof may be retained and, perhaps, monitored with increasing frequency at it continues to age.
- The underlayment is in poor condition, only two percent to five percent of the slate shingles are broken, missing, cracked, or otherwise deteriorated, but the shingles have an expected remaining service life

of only 10 to 15 years, and the roof leaks, but only in heavy or windblown rains: This is an indication that it might be prudent to replace the roof.

· The underlayment is in poor condition, the slate and flashings are in good condition and have an expected remaining service life of 30 years, but leaks occur in the field of the roof during most rain events: This is an indication that something else is going on, such as insufficient side lap, insufficient headlap, or the slates are generally too small for the given roof slope and/or climate conditions (e.g., 16x8 slates laid on a 6:12 slope in the Pacific Northwest). Further investigation may be required to determine whether roof repair or roof replacement is the most practical course of action.

Summary

This *Technical Bulletin* examined the key aspects of assessing the condi-

tion of existing slate roofs, including the slate shingles themselves, slating nails, flashings and underlayments. The end result of an assessment is often a written report containing a discussion of existing conditions, recommendations for addressing noted deficiencies, and associated construction cost estimates. When assessing the condition of slate roofs, it is prudent to take a holistic approach and examine other building materials and systems that may be impacting the slate roof, or which may need to be treated at the same time as the slate roof. Such other materials and systems include rainwater conduction systems, masonry parapets and chimneys, dormer wall cladding, architectural woodwork at eaves and rakes, skylights, roof decking, and roof framing. For example, when a slate roof must be replaced, masonry restoration work at chimneys should take place prior to replacement of the slate, not afterwards (so as not to risk damaging the newly installed slate).

Endnotes

¹Although there are many additional research-related, technical, and logistical tasks associated with performing a proper condition assessment, such as assembling survey recordation materials (e.g., roof plans and elevation drawings), interviewing the building owner regarding past maintenance practices and problem areas, research to undertake prior to surveying, and access and safety considerations, these are beyond the scope of this Technical Bulletin. For more information on the subject of condition assessments, one place to start is ASTM E2018, *Standard Guide for Property Condition Assessments: Baseline Property Condition Assessment Process*, first published in 1999. The Standard outlines the purpose and scope of building condition assessments, including such things as walk-through surveys, interviews, document reviews, identifying and recording deficiencies, and the contents of assessment reports.

²Descriptions of the roofing slate from the various commercial slate deposits of the United States and Canada can be found in the National Slate Association's *Slate Roofs: Design and Installation Manual,* 2010 Edition, pages 7-10. Color photographs of many different roofing slates can be found in the Member Project Gallery on NSA's website, www.slateassociation.org.

³There are, of course, exceptions to the estimated service lives of slates from the various regions. In the Monson, Maine, district, for example, there were two or three quarries in Brownville that produced roofing slate with an expected service life of only 75 to 85 years, as compared to the higher quality slate produced by the other 14 or 15 quarries in Monson producing slate shingles having an expected service life of 150 years. Similarly, in the Soft-Vein District of Pennsylvania, whereas most quarries produced slate shingles with an expected service life of about 60 years, Cathedral Gray, an unfading medium gray slate with an occasional olive tint, is known to have had a service life of 100 years or more. Cathedral Gray was produced in the so-called "Gray Beds" of the Albion "run," primarily in the Wind Gap/Pen Argyl/Bangor area of Northampton County, Pennsylvania, and constituted at least part of the production of such quarries as the Albion (aka Dally) Quarry, Stephens-Jackson Slate Co.

MAY 2020



Endnotes (continued)

⁴Quarries in other regions of the United States operated sporadically and for short periods of time in the late nineteenth and early twentieth centuries, primarily when demand for slate shingles was high. These quarries included those located in Rockmart, Georgia, Monroe County, Tennessee, Sussex County, New Jersey, Baraga County, Michigan, near Placerville, California, and in Slate Canyon, near Provo, Utah. For more information on minor slate deposits in the United States see the National Slate Association's *Technical Bulletin No. 3*, "Lesser Known Slate Deposits of the United States," available at www.slateassociation. org.

⁵D.W. Kessler, and W.H. Sligh, "Physical Properties and Weathering Characteristics of Slate," *Bureau of Standards Journal of Research*, Vol. 9 (Washington, D.C.: U.S. Department of Commerce, Bureau of Standards, 1932), p.401.

⁶Reinstallation of slate shingles with the same exposure as the original installation is not always possible. In the past, it was not unusual for slate shingles to be laid with insufficient headlap. For example, if the slate on a roof with a slope of 12:12 was laid with a 2" headlap and is to be salvaged and re-laid, it will have to be reinstalled with a 3" headlap in order to meet the requirements of modern-day building codes (and good practice). This will reduce the exposure of the shingles, thereby hiding the ghost lines of the previous exposure. If, on the other hand, salvaged slate originally laid with a 4" headlap is to be re-laid with a 3" headlap, the exposure will be greater and the ghost lines of the original exposure will be visible.

⁷Additional information on the assessment and maintenance of roof flashings can be found in *Architectural Sheet Metal Quality Assurance Guide*, First Edition, Sheet Metal and Air Conditioning Contractor's National Association, Inc. (SMACNA), Chantilly, Virginia, 2015.

³Inconsistent spacing of base flashings can result in insufficient laps and the potential for leakage during precipitation events.

For more information on slate roofing, please see *Slate Roofs: Design and Installation Manual*, 2010 Edition, available at www.slateassociation.org



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