Designation: D7053/D7053M – 17

Standard Guide for Determining and Evaluating Causes of Water Leakage of Low-Sloped Roofs[1]

This standard is issued under the fixed designation D7053/D7053M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide describes methods for determining and evaluating causes of water leakage in low-sloped roofs. For this purpose, water penetration is considered leakage and therefore problematic, is causing or is likely to cause premature deterioration of the roof, building or its contents, or is adversely affecting the performance of other components of the building. A roof is considered an assembly including the membrane, insulation, vapor retarder (if required), deck, and structural components.

1.1.1 This guide excludes moisture-related problems in roofs caused by condensation.

NOTE 1—*Condensation*—Moisture-related problems in roof systems may be caused by condensation of humid air originating from within the building and be incorrectly attributed to leakage from rain water. The protocol for an investigation of dampness due to condensation and is complicated, requires special expertise, and is beyond the scope of this guide. For information regarding condensation problems as they relate to roofs, refer to ASTM MNL 18,[2] ASTM MNL 40,[3] and ASHRAE Handbook 2005 Fundamentals.[4]

1.2 Investigative techniques discussed in this guide may be intrusive, disruptive, or destructive. It is the responsibility of the investigator to establish the limitations of use, to anticipate and advise of the destructive nature of some procedures, and to plan for repairing and selective reconstruction as necessary.

1.3 This guide does not address steep-sloped roofs, standing or flat seam metal roofs, or architectural standing seam metal roofs.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[5]

C1153 Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging

D1079 Terminology Relating to Roofing and Waterproofing

D7186 Practice for Quality Assurance Observation of Roof Construction and Repair

3. Terminology

3.1 Refer to Terminology D1079.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *condensation*—the conversion of water vapor to liquid as the temperature drops or atmospheric pressure rises.

3.2.2 *water leakage*—the passage of (liquid) water through a material or system designed to prevent the passage of water.

4. Significance and Use

4.1 This guide is intended to provide building professionals with a methodology for evaluating water leakage through low-sloped roofs. It addresses the service history of a roof, the various components of a roof, and the interaction between these components and adjacent construction. It is not intended as a construction quality control procedure, as specified in Practice D7186, nor as a preconstruction qualification procedure. It is intended for evaluating water leakage through a low-sloped roof.

4.1.1 *Qualifications*—Use of this guide requires a background as an architect, engineer, roof/waterproofing consultant, roofing contractor, or related profession with an understanding in building construction and the expertise in the design, installation, and maintenance of low-sloped roofs.

[1] This guide is under the jurisdiction of ASTM Committee D08 on Roofing and Waterproofing and is the direct responsibility of Subcommittee D08.20 on Roofing Membrane Systems.

Current edition approved Jan. 1, 2017. Published January 2017. Originally approved in 2007. Last previous version approved in 2011 as D7053/D7053M – 11. DOI: 10.1520/D7053_D7053M-17.

[2] Treschel, H. R., ed., *Manual on Moisture Control in Buildings,* MNL 18, ASTM International, 1994.

[3] Treschel, H. R., ed., *Moisture Analysis and Condensation Control in Building Envelopes,* MNL 40, ASTM International, 2003.

[4] *ASHRAE Handbook 2005 Fundamentals,* available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, http://www.ashrae.org.

[5] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4.1.2 *Application*—The sequential activities described herein are intended to produce an evaluation program, but all activities may not be applicable or necessary for a particular evaluation program. It is the responsibility of the professional using this guide to determine the activities and sequence necessary to perform an appropriate leakage evaluation for a specific low-sloped roof on a building.

4.1.3 *Preliminary Assessment*—A preliminary assessment may indicate that water leakage problems are limited to a specific element or portion of a low-sloped roof. The evaluation of causes may be limited in scope, and the procedures recommended herein abridged according to the professional judgment of the investigator. A statement stipulating the limits of the investigation should be included in the report.

4.1.4 *Expectations*—Expectations about the overall effectiveness of an evaluation program must be reasonable, and in proportion to a defined scope of work. This guide is intended to address leakage of a low-sloped roof system, leading to conclusions that can generally be applied to similar or other locations on the roof. Since every possible location is not included in an evaluation program, it is probable that every leak source will not be identified. Leak sources that are localized and unique may remain, and require specific and localized evaluation effort.

4.2 This guide is not intended as a design guide. Reference is made to design features of a low-sloped roof only for the purpose of identifying items of interest for consideration in the evaluation process.

4.3 This guide does not address leakage through walls not associated with roof construction, fenestration, or leakage below-grade. It is not intended for use with structures designed to retain water, such as pools, fountains, and vegetative roofs.

SYSTEMATIC APPROACH TO AN EVALUATION

5. Overview

5.1 The methodology presented in this guide is intended to provide a systematic approach to evaluating roof leaks, and is applicable to any low-sloped roof system. The sequence of activities is intended to lead to an accumulation of information in an orderly and efficient manner, so that each step enhances and supplements the information gathered in the preceding step.

5.1.1 *Sequence of Activities*—The recommended sequence of activities, discussed in individual sections below are:

5.1.1.1 Review of project documents.

5.1.1.2 Evaluation of original roof design concept.

5.1.1.3 Determination and review of service history.

5.1.1.4 Inspection.

5.1.1.5 Investigative testing.

5.1.1.6 Analysis.

5.1.1.7 Report preparation.

5.2 *Analysis and Interpretation*—The information gathered during a leakage evaluation is analyzed as it is acquired. It is not the intent of this guide to imply that the analysis and interpretation of the information occurs only at the completion of all activities.

6. Review of Project Documents

6.1 Ideally, project documents, including roof component shop drawings, will be available and accessible for review. The discussion in this section assumes that a project was organized on a conventional owner/design professional/contractor model. Projects can be delivered in various ways, and the method used will dictate the appropriate organization of the project documents. The information discussed below should be available for review somewhere in the project documents.

6.1.1 *Design, Bidding, and Contract Documents*—These documents include architectural and engineering drawings, specifications, and may include correspondence, meeting minutes, addenda, substitution proposals, product literature, test reports, survey reports prepared by others, shop drawings, and so forth. They contain the information necessary to understand the performance criteria, the design intent, materials, and relationships among the roof components.

6.1.1.1 Documents may be revised or supplemented over the course of construction. Revisions to drawings are typically recorded by number and date, with a cross reference to other accompanying documents. Reviewing all revisions and understanding the differences between them and the reason for the differences is part of the evaluation.

6.1.1.2 Documents with the most recent issue date and the highest revision number establish the requirements for the project. A set of documents marked “as-built” or “record set” are intended to show the actual construction and may be available.

6.2 *Referenced Codes and Standards*—Project documents usually contain references to regulatory codes, industry standards, or manufacturer installation requirements. Standards, referenced codes, and manufacturer information often contain default or minimum criteria to establish the performance criteria for the roof. Conflicts between the referenced documents and those stated in the project documents should not be assumed to be a cause of leakage without further investigation.

6.2.1 Regulatory codes, industry standards, and manufacturer installation requirements change over time. The version of these documents examined as part of the review of project documents should be those listed with dates in the project documents, or if not listed with dates, those in effect when the building permit was issued.

6.3 *Submittals*—Additional documents are generated after the award of contracts and are submitted to the design professional for review and inclusion in the project record. The submittals usually apply to a specific material, component, assembly, or installation method, and the information contained will augment the project documents. There can be a number of revisions to submittals prior to final approval. The standard for the project is set by the submittals approved by the design professional. Submittals can include shop drawings, test reports, product literature, manufacturers’ recommendations, installation and maintenance guidelines, warranties, etc.

6.3.1 Test reports provided by manufacturers and suppliers should have been performed by an independent laboratory or witnessed by an independent agency (if requested by the

customer). Review the test dates and the description of what was tested to determine if and how the information actually applies to the project.

6.3.2 Manufacturers' and suppliers' information, and the exclusionary language in warranties, may suggest circumstances under which one or more of the components may not function properly. Project conditions should be evaluated to determine if an appropriate product selection had been made.

6.3.3 Submittals should be reviewed for maintenance recommendations and guidelines.

6.4 *Pre-Qualification and Mock-Up Reports*—Compliance with specific project requirements may have been demonstrated by a mock-up test. The mock-up report should contain a clear and complete description of changes necessary to pass the test. Project documents should incorporate these changes, and they should be reflected in the actual construction. Failure to incorporate these changes should be considered as a possible cause of water leakage.

6.5 *Additional Construction Documents*—Additional construction documents that record changes, decisions, and activities during the construction phase may include bulletins, requests for information (RFI), clarifications, change orders, directives, progress photos, inspection and quality assurance reports, test reports, meeting minutes, and correspondence. The information in these documents may modify or supersede the design documents.

6.6 *Local Practices*—An understanding of local practices will permit a thorough assessment of the project roof design and construction. The actual construction may be influenced in an undocumented manner by local practices.

6.7 *Missing Documents*—Project documents may be unavailable or have missing parts. This situation will require the determination of existing and as-built conditions. The information may need to be generated from observations and measurements of the building.

7. Evaluation of Design Concept

7.1 *Design Concept*—Review of the project documents should reveal what requirements had been specified for the roof.

7.2 *Efficacy of the Design*—The design shall include properly selected components. The details must provide for the interfacing and integration of components so that each one can perform collectively and function as a system. The details must also address issues such as construction tolerances, material compatibilities, terminations, penetrations, and building movement. A careful evaluation of the design will indicate inconsistencies that may contribute to leakage.

7.3 *Exposure*—Based on an analysis of local weather conditions and the location and geometry of the building, identify the actual weather conditions during periods of leakage. These conditions can be correlated with service history, described in the next section, to help establish a protocol for the evaluation process.

8. Determination of Service History

8.1 Gathering information on the service history related to leakage problems serves two purposes. First, patterns in the observed leakage and visible damage can provide an indication of the cause(s) and where to focus an investigation. Second, the information provides a checklist against which failure theories and conclusions can be evaluated. A comprehensive diagnostic program should result in an explanation for most, if not all, aspects of the observed leaks and damage.

8.1.1 *Document Physical Symptoms of Leaks:*

8.1.1.1 Make a detailed visual inspection of both the interior and exterior. Locations that should be checked for indications of leakage include but are not limited to:

(1) Intersection of the roof with walls, parapets, and curbs.
(2) Perimeter gravel stops.
(3) Roof drains, overflow drains, and scuppers.
(4) Base flashing.
(5) Roof slope.
(6) Mechanical units.
(7) Curbs and equipment rails.
(8) Expansion joints.
(9) Field seams and laps.
(10) Punctures, splits, or tears in membrane or flashing.
(11) Utility and building service penetrations.
(12) Gutters and downspouts.
(13) Cap flashing.
(14) Pitch pans.
(15) Door sills.
(16) Penthouse or parapet walls.
(17) Counterflashings.
(18) Surface-mounted flashing.
(19) Reglets.
(20) Weep holes in masonry walls.

8.1.1.2 Note all locations of past and existing water damage, including, but not limited to, the following:

(1) Wet, damp, or water-saturated surfaces in the building interior.
(2) Color differences caused by organic growth, staining, or corrosion in the building interior.
(3) Staining, indicating the flow or accumulation of water.
(4) Interior areas repaired or patched due to prior leakage.
(5) Blistering surface of interior finishes that can indicate wetting.

8.2 *Interviews*—Interview occupants, maintenance personnel, subcontractors, tradesmen, or other first-hand observers. Obtain information that will help correlate leakage with building features and other events, such as:

8.2.1 The apparent origination point of a leak.

8.2.2 The exterior environmental conditions under which the leak occurs.

8.2.3 The frequency and initiation of occurrence, especially if the occurrence is exceptional or occurs under extreme conditions.

8.2.4 For leaks that occur during rains, ascertain if a leak:

8.2.4.1 Occurs immediately after the onset of rain or after a period of time elapses.

8.2.4.2 Stops immediately when the rain stops, or continues for a period of time after the rain ends.

8.2.4.3 Occurs during every rain regardless of severity.

8.2.4.4 Occurs during every rain regardless of wind direction, or only with wind from certain directions.

8.2.4.5 Occurs during or immediately after cold weather, with or without accompanying rain.

8.2.4.6 Occurs because of different interior environmental conditions and the building operations. Weekend and evening operating conditions may differ from weekday business hour conditions.

8.2.4.7 Appears to be related to a particular feature or detail.

8.2.4.8 Is caused by the performance of the building piping system, including water supply and drainage, heating and air conditioning supply and return, and roof drains. Leaks from a piping system might be misinterpreted as a roof leak.

8.3 *Maintenance and Repair Records*—Buildings with chronic leakage problems are often subjected to several attempts at remediation before a comprehensive evaluation is made. An effort should be made to understand the earlier attempts at repairs because: (*1*) they may indicate a pattern of leakage; (*2*) repairs may be causing or contributing to current leakage; and (*3*) it will be necessary to distinguish between original construction and attempted repairs during the inspection and testing phases of a systematic evaluation. Where appropriate and possible:

8.3.1 Review the original project punch-list if available. Water leakage problems can often occur because of stopgap repairs made in an effort to closeout the project.

8.3.2 Review purchase orders for building maintenance and repair records and other activities that may relate to water leakage problems.

8.3.3 Review work orders that deal repeatedly with the same leakage problem.

8.3.4 Evaluate the success or failure of previous repair attempts.

8.3.5 Compare original details to actual conditions observed to determine deviations from original construction intent or undocumented repair attempts.

8.3.6 Identify repairs that inadvertently seal weep holes in walls or parapets or other openings that are intended to dissipate or weep entrapped water in a wall system. These might have been sealed in an attempt to stop a roof leak.

8.3.7 Evaluate repairs against the original design intent. Common repairs made to leaking roofs include the application of roof cement, sealant, coating, incompatible or different roof membrane material, and underdeck gutter systems. Inappropriate use of these procedures can cause additional problems.

8.4 *Determine Extent of Leakage*—Use the information gained above to determine the extent of leakage.

8.4.1 Correlate historical leak occurrences with particular building features and details.

8.4.2 A graphical analysis is useful for correlation studies. Leak occurrences can be superimposed on building drawings to help reveal patterns that might be traceable to potential leak sources.

8.5 *Weather Records for the Vicinity:*

8.5.1 Detailed weather data for a specific time period, typically recorded at major airports, can be obtained from the National Weather Service. The data of particular interest for a leakage evaluation are: precipitation rate, wind speed during precipitation, wind direction, barometric pressure, and relative humidity.

8.5.2 Unusual events and severe leakage occurrences should be correlated.

8.6 *Correlations*—Correlate occurrence with other factors such as temperature, wind direction and speed, season of year, and building operations.

8.6.1 *Temperature*—Ambient air temperature and roof surface temperature can affect water leakage.

8.6.2 *Wind Direction and Speed*—A primary force for water leakage is wind-driven rain. The severity and location of leakage can often be correlated to the direction and speed of the wind.

8.6.3 *Season of Year*—Some buildings in northern climates only leak during the winter months. The accumulation of ice and snow on horizontal surfaces can feed water into a roof assembly during clear cold sunny days even when the outside temperature stays below freezing.

8.6.4 *Building Operations*—Although most building HVAC systems operate on positive pressure, parts of the building could be subjected to negative interior pressures when exposed to certain wind conditions. Building operating pressures are usually very small compared to the effect of wind, and are rarely the sole cause of leakage in occupied spaces. However, in the vicinity of louvers and equipment spaces, mechanically induced pressures can be significant.

8.6.5 *HVAC System Plenums*—The space between the underside of the roof deck and the interior ceiling can be an open return air plenum or a closed ducted plenum. Either system, including unsealed return air ducts, can pull untreated air through the building exterior walls, and cause condensation in both humid and cold climates. Cold air will chill surfaces, and internal humidity will condense. In hot climates, humid air that infiltrates can condense on cold surfaces inside the building.

9. Inspection

9.1 *Presentation*—Composite large-scale drawings are helpful in gathering and recording information about as-built conditions. A composite drawing can begin with the best available information from the project documents including pertinent information from the architectural, structural, and mechanical drawings and specifications, as well as the structural and roof assembly shop drawings. The drawing can serve as a form for recording actual field conditions. Differences between information in the project documents and the as-built conditions should be anticipated. These differences do not necessarily mean that a leak source has been identified. The purpose is to provide a basis for further inspection, testing, and remedial recommendations.

9.2 *Determine Current Conditions*—The physical condition of the roof and visible evidence of water leakage should be documented during the inspection. This information can then be correlated with information from the service history of the roof in formulating a hypothesis about the cause(s) of leakage. Examples of information that should be documented include:

9.2.1 Condition of flashing.