ANSI/SPRI/RCI NT-1

Detection and Location of Latent Moisture in Building Roofing Systems by Nuclear Radioisotopic Thermalization

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Disclaimer
This standard is intended for use by architects, engineers, roofing contractors, and owners of low-slope roofing systems. SPRI, its members and employees do not warrant that this standard is proper and applicable under all conditions.

1.0 Scope

1.1 Radioisotopic thermalization, performed in accordance with this standard, can effectively be used in the roofing industry to:

1.1.1 Locate and quantify latent moisture contained in the roofing material and/or roof deck materials.

1.1.2 Locate hidden sources of moisture entry by tracing subsurface paths of moisture migration.

1.1.3 Provide a basis for investigating roofing material and/or roof deck material degradation over a period of years when used as part of a preventive maintenance program.

1.2 This standard provides a minimum set of procedures for conducting surveys of moisture in membrane roofing systems, and for analyses of the data obtained in such surveys. Included are operating, verification, and reporting procedures, as well as operator qualification criteria.

1.3 This standard addresses the effect of roof construction, material differences and roof conditions on the numerical data output provided by the nuclear equipment.

1.4 This standard addresses limitations in the use of radioisotopic thermalization.

1.5. This standard addresses the governmental control of the equipment used to conduct nuclear moisture surveys.

2.0 Terminology/Definitions

2.1 Agreement States
Certain States that have an agreement with the United States Nuclear Regulatory Commission (USNRC) which permits these States to control, within the State, those radioactive materials for which the USNRC is responsible.

2.2 Backscatter
The number of neutrons reflected back in contrast to the number passing through a substance.

2.3 Film Badge
Photographic film used to measure exposure to ionizing radiation for purposes of personnel monitoring. See Commentary C2.3.

2.4 Radioisotopic Thermalization
The process undergone by high-energy (fast) neutrons as they lose energy by collision. Thermalization occurs when the energy of fast neutrons is partially absorbed by moderators of hydrogen atom collision.

2.5 United States Nuclear Regulatory Commission (USNRC)
The U.S. Nuclear Regulatory Commission (NRC) was created as an independent agency by Congress in 1974 to ensure the safe use of radioactive materials for beneficial civilian purposes while protecting people and the environment. The NRC has jurisdiction over licensing requirements for nuclear sources in the United States. Many other countries will have a similar agency with jurisdiction.

3.0 Survey Equipment and Licensing Requirements

3.1 The equipment shall be specifically designed for performing roof moisture surveys. An isotopic radioactive source consisting of Americum-241, Radium 226, or Cesium 137 with a Beryllium target is required.

3.2 The possession and use of by-product radioactive material in the US requires a license issued by the United States Nuclear Regulatory Commission (USNRC) or the equivalent agency of a State which has entered into an agreement with USNRC to assume control over the distribution. The following applies within the US, and many foreign countries have similar regulations.

3.2.1 Certain States have an agreement with the USNRC which permits these States to control, within the State, those radioactive materials for which the USNRC is responsible. These States, known as “Agreement States,” have, in general, enacted laws and regulations for the control of radioactive material.

3.2.2 Most “Agreement States” have a reciprocity clause in their regulations that permits a user, licensed in his own State, to operate in another State for certain periods of time. Prior notification to the visited State is generally required.

3.2.3 Licensing requirements can differ depending upon the radioactive element being used in the equipment.

3.3 Commercially available equipment utilized for radioisotope thermalization shall be capable of meeting the requirements of the governing regulatory agency.

3.4 Since changes are continuously made governing regulation, the user shall stay current with the appropriate regulations. Responsibility for compliance with the regulations falls upon the owner of the equipment.

3.5 Licensing Considerations

3.5.1 User Training
The user shall complete an approved training program provided by the equipment manufacturer or other organization acceptable to the licensing authority.

3.5.2 Manufacturer’s Instruction Manual
Each user shall have access to and be familiar with the equipment manufacturer’s instruction manual.

3.5.3 Storage, Transportation, and Use
The equipment shall be stored in a locked area, base down, and in contact with shielding material such as concrete. Transportation shall be in an approved shipping container approved and labeled for use by the governing agency (typically provided by the equipment manufacturer), secured against removal by unauthorized personnel, and be accompanied by a current “Shipper’s Certification for Radioactive Materials”. During cleaning and use of the equipment, the operator shall avoid direct contact with the base of the equipment and shall instruct others to do likewise.

3.5.4 Radiation Leak Testing
Radiation leak tests shall be performed in accordance with the manufacturer’s specifications, at prescribed intervals, and in accordance with the procedures designated by the licensing authority.

3.5.5 Maintenance and Servicing
The user shall not be authorized to remove the source or perform any maintenance on the source or source holder. These services shall be performed by the equipment manufacturer or other persons specifically licensed to perform these operations.

3.5.6 Personal Protection
Unless otherwise allowed by the Governing Agency having jurisdiction, all users shall be provided with film badge type dosimeters to be worn when handling or using the equipment. Authorized personnel, meeting the requirements of part 4 below, shall see to it that other persons are kept away from the equipment during use, transportation, or storage.

3.5.7 Waste Disposal
The equipment containing radioactive material shall be disposed of by either:

3.5.7.1 Transfer to another specifically licensed user or disposal agency.

3.5.7.2 Return to equipment manufacturer.

3.6 Moisture Detection

3.6.1 Fast neutrons from the radioactive source are involved with moisture content measurements. Fast neutrons from the radioactive source enter the material being surveyed and are both scattered and slowed down by collision with the nuclei of the atoms composing the material. Nuclei of all materials slow down the neutrons by momentum exchange, but the speed reduction is greatest for collisions with hydrogen nuclei, which have about the same mass as the neutrons. When water or moisture is present more hydrogen atoms exist for collisions. Some of the slow neutrons or thermal neutrons are scattered in such a way that they reach the slow neutron detector and are counted for a specified period of time.

3.6.2 In general, the detector measures the backscattering of slow neutrons that have collided with hydrogen nuclei. The resulting numerical readout displayed by the equipment is a relative measurement of hydrogen present in the material at the point of survey. It is important to note that elevated readings can be influenced by sources of hydrogen other than moisture content, i.e., bitumen thickness, wood deck, etc.

4.0 Survey Personnel

4.1 The moisture survey shall be performed under the supervision of a Survey Director. The Survey Director shall be thoroughly trained in the operation of the equipment and radiation safety, and have a thorough understanding of modern roofing technology, including knowledge of:

4.1.1 Types of roofing membrane material and the aging process.

4.1.2 Construction procedures.

4.1.3 Types of roofing insulations.

4.1.4 Types of roofing decks.

4.1.5 Types of roof assemblies.

4.1.6 Equilibrium moisture contents.

4.1.7 Effects of structural building components on moisture survey results.

4.1.8 Moisture migration in buildings.

4.2 The Survey Director shall have completed the following training:

4.2.1 Operational and radiological safety training conducted by the manufacturer of the equipment being used.

4.2.2 Previous field experience in this surveying discipline with “hands on application,” for a period of not less than two (2) years.

4.3 All other personnel involved in the survey shall have been instructed in radiological safety, equipment operation, rooftop safety, and basic roofing technology.

5.0 Survey and Analysis Procedures

5.1 Preparation

5.1.1 Prior to or as part of the nondestructive nuclear evaluation, a physical roof survey is required to visually determine areas that are not safe for access by persons required to perform the survey. To assist with the physical roof survey secure architectural or structural drawings (if possible), verify composition of existing roof materials, and solicit historical information pertaining to the roof system performance. See Commentary C5.1.1.

5.2 Execution

5.2.1 Establish a reference point for each roof section to be surveyed. A roof section is an area of homogeneous roof construction. The reference point shall be located to permit horizontal (x-axis) measurements to the right of the reference point when facing the reference point and vertical (y-axis) measurements toward the viewer when facing the reference point. All measurements relating to x-y coordinates and the location of structural elements of the building rising above the roof surface, roof penetration(s), and/or membrane defects shall be made from this reference point.

5.2.2 The entire roof area to be surveyed shall be laid out with a grid based upon the x-y coordinates. Distance between the x-y coordinates shall be determined by the Survey Director and shall be consistent in each direction resulting in a pattern best suited to provide an adequate number of equipment readings to permit a thorough evaluation. Grid size will be influenced by the size and configuration of the roof section being surveyed and the material make up of the roof system (see Table 1).

5.2.2.1 Equal x-y coordinates [e.g., 10 ft X 10 ft US or 3 m X 3 m Metric, 6 ft X 6 ft US or 2 m X 2 m Metric, or 3 ft X 3 ft US or 1 m X 1 m Metric] in even increments and whole or half units of measure (US or Metric applied) shall be used. The distance between x-y coordinates shall not be greater than ten (10) feet US or three (3) meters Metric). Five feet US or 1.5 meters Metric is typically recommended. The distance between x-y coordinates used shall be consistent throughout the roof section being tested. A smaller increment between readings does improve the results by reducing the distance between readings but also increases the work required to provide the results. See Commentary C5.2.2.1.

5.2.2.2 x-y coordinates shall be located such that readings will not be required on the increased material thickness at perimeters and penetration flashings. One method of avoiding the extra material thickness is to come off the exterior perimeters and away from all penetration flashings a distance of two (2) to three (3) feet (one meter). In the field of the roof, areas of increased material thickness that cannot be avoided shall be treated as a separate roof section for analysis purposes.

5.2.2.3 x-y coordinate markings shall be made on the roof surface and on wall flashings around the perimeter of the area being surveyed to allow for identification of readings obtained for sampling and further investigation. Obtain permission from the building owner prior to the use of permanent marking material. Ensure that marking material is compatible with the surface being marked.

5.2.2.4 All structural elements of the building rising above the roof surface, penetrations, and obvious patched areas shall be accurately recorded on the recording sheet.

5.2.2.5 Prior to taking nuclear readings the device shall be tested on the roof to confirm it is functioning properly by taking ten readings in the same location without moving the equipment and recording them. When the equipment is functioning properly 99.7% of the readings recorded will fall between the plus or minus three (3) standard deviation limits established by the manufacturer for the equipment.

5.2.2.6 Nuclear readings shall be taken and recorded at each x-y coordinate or grid point. See Commentary C5.2.2.6.

5.3 Limitations

5.3.1 In order for this technique to be useful in detecting moisture, the material thickness is required to be constant (+/- 10 percent). Extra thickness of material, that normally occurs at flashings, penetrations, walkway layers, and patches, can alter the material thickness or reference level of the material composition being surveyed.

5.3.1.1 Over a deck or above-deck materials of varying thickness, the reference level can be altered (e.g., significantly tapered insulation material, precast tees, or waffle form decks).

5.3.1.2 A change in material below the roof membrane surface (e.g., metal deck vs. concrete deck; isocyanurate (polyisocyanurate) vs. fiberboard; additional plies of roofing material) can alter the reference level.

5.3.1.3 Heavy, moist, and dirty gravel can alter the reference level.

5.3.1.4 Equipment readings shall not be taken as part of a roof section survey in areas covered with standing water, ice, or snow. If nuclear readings must be taken in these areas, they shall be analyzed as a separate roof section, and must include a uniform covering of water, ice, or snow.

5.3.1.5 Roof assemblies composed of multiple layers of various materials derived from roof recover operations can alter the reference level.

5.3.2 For ballasted membranes and protected membrane roof (PMR) assemblies, the aggregate or paver ballast shall be removed in appropriate x-y coordinate spacing throughout the roof area in order to obtain equipment readings directly against the roof membrane and underlying insulation layers (if any). If the protective insulation layer of a PMR is left in place for the equipment reading, the core samples shall include this layer, since its moisture absorption level could adversely affect the overall survey.

5.3.3 Nuclear radioisotopic thermalization techniques for determining moisture contents of materials shall not be used over metal roof systems.

6.0 Verification and Quantification

6.1 General

6.1.1 The field data (numeric readout) is only relative and shall be quantified by core cuts. Three or more cores shall be extracted, with a core extracted at a general low (but not the lowest) reading, intermediate reading, and high (but not the highest) reading for each roof section surveyed. Core size shall not be less than a nominal two (2) inches (50 mm) in diameter and shall include all material down to the deck. If the deck material is capable of moisture absorption, a portion of it shall be included (structural concrete cores are not required). See Commentary C6.1.1.

6.1.2 Each element (membrane, each insulation layer, if they are not multiple layers of the same material within the extracted cores) shall be immediately sealed in separate moisture tight containers and labeled to identify the date, location (building, roof section, and x-y coordinate), person taking the core, and any other information required by the Survey Director.

6.1.3 The core cuts to provide samples for testing shall be extracted directly after the equipment readings have been completed for the roof section to assure the core cuts are taken from the correct x-y coordinate point relational to the equipment reading obtained.

6.1.4 Core samples shall be analyzed for moisture content by weight. Separate different elements of the roof assembly, such as insulation layers and construction material layers (without damaging materials), and perform gravimetric analysis (see 6.2) separately for each layer of each core sample (i.e., membrane, insulation, base sheet, vapor retarder, moisture sensitive deck, etc.).

6.1.5 Sampling and the repair of core cuts made shall be accomplished in accordance with the manufacturer's recommendations and/or *NRCA Repair Manual for Low-slope Membrane Roofing*.

6.2 Gravimetric Analysis

6.2.1 The different elements of the roof assembly (see 6.1.4) shall be separated at the time of sampling and analyzed separately. Each element (deck, vapor retarder, insulation, and membrane) shall be weighed immediately after removing from the sealed container. The sample container and material extracted from the roof shall be chamber dried for a minimum of 24 hours at 220º F/104.4º C and re-weighed. The chamber drying procedure shall continue until no weight loss is observed (within limits of balance equipment). Moisture content by weight is determined by the following formula:

[(Wet weight-Dry weight)/Dry Weight] x 100

[Eq. 1]

See commentary C.6.2.1.

6.2.2 A determination of moisture content by dry weight shall be made for each analyzed material. For bituminous built up roof membrane materials moisture content shall be determined by ASTM D95, *Standard Test Method for Water in Petroleum Products and Bituminous Materials by Distillation*.

7.0 Analysis of Collected Data

7.1 The interpretation of the nuclear equipment readings and the correlation of core sample test data shall be accomplished by the Survey Director. See Commentary C7.1.

7.2 Once the actual moisture content levels have been determined for the low, mid, and high readings, a straight line graph shall be drawn relating count rates to actual moisture levels. The measurement counts must be converted to a defined unit of measurement, such as percent moisture (See Table 2).

7.3 Histogram

The volume of data collected is normally voluminous. A histogram shall be prepared to compile the data into a compact form. A histogram simply groups data points by defining intervals and combining all data points that fall within that interval.

7.3.1 The interval size shall be carefully considered; it shall be large enough to ease the computational task, but small enough to easily distinguish the normal distribution produced by the dry sections of a dry roof (See Table 3).

7.3.2 The normal distribution curve shall be calculated for the main part of the data, with the three-sigma limits corresponding roughly to the acceptable moisture limits for "dry" insulation of the materials being considered (See Table 4).

7.4 Graphic Plot

Once the wet areas can be defined from the count rate data, a graph of the roof plan shall be drawn to summarize the survey. The moisture map shall be prepared depicting a minimum of three (3) levels of moisture content (See Table 2) per material tested. The graphic plot (moisture map) shall be prepared by computer program, hand contouring, or colored graphics within a spreadsheet program. If possible, the graphic plot of suspected wet areas shall be overlaid onto scaled drawings of each surveyed section roof and compared to architectural and structural drawing available to determine potential impact of latent building and structural features on the collected field data. See Commentary C7.4.

7.5 Statistical Analysis of Data

7.5.1 Statistically, the histogram produced by using a nuclear gauge on a dry roof section will form a bell-shaped curve. This curve is called the “normal distribution.” Two conditions shall be met to produce a statistically meaningful curve:

7.5.1.1 The roof section must be of similar composition throughout.

7.5.1.2 A minimum of 100 data points shall be taken within the roof section to allow the normal distribution to appear.

7.5.2 The “width” of the normal distribution is determined by the standard deviation of the main data. The importance of the standard deviation is that once the mean (average) and the standard deviation are known, the “end points” of the normal distribution, and therefore the count rate range for dry areas of the roof, can be defined.

7.5.3 The normal distribution curve shall be overlaid on the measurement data histogram. To verify the end points for the overlay process, the mean and standard deviation must be calculated for the main data (excluding extreme outlying data points). The mean is simply the sum of the midpoint of the histogram interval multiplied by the frequency of occurrence and divided by the total number of points. The equation is:

$$\textbf{Mean} = (Xi \times Fi) / N \qquad \text{[Eq. 2]}$$

7.5.4. The equation for standard deviation for grouped data is:

$$\frac{\left\{ \dfrac{[(Xi)^2 \times Fi]-[Xi \times Fi]^2}{N} \right\}^{1/2}}{(N-1)^{1/2}} \qquad \text{[Eq. 3]}$$

Where
Xi = the midpoint of histogram interval

Fi = Frequency of occurrence

N = Total number of points

Note: These equations are easily implemented with a programmable calculator, computer, or spreadsheet

8.0 Precision & Bias

8.1 Precision, 99.7% of the measurement counts for the dry areas of the roof will fall between the plus or minus three (3) standard deviation limits.

8.2 Bias, since there is no accepted reference material suitable for determining bias for this test method, bias has not been determined.

9.0 Reporting

9.1 The Nuclear Roof Moisture Survey Report shall include, at a minimum, the following information:

9.1.1 Description of methodology.

9.1.2 Identification of existing roof construction and the make and model of the nuclear equipment used.

9.1.3 A record of all nuclear readings including the ten test readings taken on the roof prior to the start of the survey confirming proper function of the equipment.

9.1.4 Analysis of data, including moisture content charts correlating to the moisture map.

9.1.5 A scaled drawing depicting at least three (3) distinct moisture levels and including major roof top structures and penetrations.

9.1.6 A histogram summarizing all data collected.

9.1.7 Record of laboratory gravimetric analysis of extracted core cuts.

9.1.8 A record of all core cuts including precise location.

9.1.9 A statement of basis for unacceptable moisture content levels established for each material present. See Commentary C9.1.9.

Table 1
Moisture Levels Computed From Gravimetric Analysis of Core Samples (Example)

Moisture Levels Based on Core Cuts		
Core #1 =	1.4% Membrane	2.4% Insulation
Core #2 =	2.2% Membrane	223.0% Insulation
Core #3 =	3.1% Membrane	443.7% Insulation

Table 2
Moisture Contour Levels (Example only)

Moisture Level	Moisture in Plies	Moisture in Insulation	Sq. Ft. of Area
1 (Low)	1.4%	2.4%	1,540
2	1.8%	112% (Interpolated)	14,730*
3	2.2%	223%	619*
4	2.6%	333% (Interpolated)	357*
5 (High)	3.1%	444%	111*

*Water Saturated Areas Requiring Removal

Table 3
Moisture Content of Roofing Materials
See commentary

Type Material	Equilibrium Moisture Content at 90% RH 75° F	Maximum Moisture Content Obtained by Immersion
Organic Felt Membrane	1.0%	20%
Fiberboard	12.0%	430%
Perlite Board	4.0%	580%
Glass Fiber	2.0%	610%
Urethane	6.0%	520%
Expanded Polystyrene	3.0%	540%
Lightweight Concrete	6.0%	110%
Dry Asphaltic Fills	0.1%	60%
Cellular Glass	0.01%	30%
Extruded Polystyrene	0.5%	10% to 15%

Source: Anderson, Richard G., "Dry Range and Wet Range Moisture Content of Roofing Materials as Found in Existing Roofs." *Proceedings of the 1985 International Symposium on Roofing Technology: A Decade of Change and Future Trends in Roofing*, National Roofing Contractors Association, Chicago, 1985

Table 4
Equilibrium Moisture Content and Moisture Content at 80% TRR
See commentary

(TRR = thermal resistance ratio)

Insulation	Equilibrium M.C. (% of dry weight)		Moisture Content (% of dry weight) at 80% TRR
	at 45% RH	at 90% RH	
Cellular Glass	0.1	0.2	23
Expanded Polystyrene [16 kg/m^3 (1 .0 pcf)]	1.9	2.0	383
Extruded Polystyrene	0.5	0.8	185
Fibrous Glass	0.6	1.1	42
Isocyanurate	1.4	3.0	262
Perlite	1.7	5.0	17
Phenolic	6.4	23.4	25
Urethane	2.0	6.0	262

Source: Griffin, C.W., and Fricklas, R.L., *Manual of Low-Slope Roof Systems*, Fourth Edition. The McGraw-Hill Companies, Inc., New York, 2006, Table. 5.2, pg.81.

Table 5
Moisture Content at 80% TRR
See commentary

(TRR = thermal resistance ratio)

Type Material	(% of dry weight)	(% of volume)
Cork	39	9.9
Fibrous Glass	15	4.4
Perlite	17	2.7
Fibrous Glass	42	6.2
Cellular Glass	23	3.1
Gypsum	8	7.0
Lightweight Concrete 369 kg/m3 (23 pcf)	10	3.7
Lightweight Concrete 594 kg/m3 (37 pcf)	9	5.3
Expanded Polystyrene [16 kg/m3 (1 .0 pcf)]	383	6.1
Expanded Polystyrene [32 kg/m3 (2.0 pcf)]	248	7.2
Expanded Polystyrene [48 kg/m3 (3.0 pcf)]	82	4.3
Extruded Polystyrene	185	5.9
Urethane/Isocyanurate	262	8.8
Foamed-in-place urethane	130	6.5
Phenolic	25	1.0

Source: Griffin, C.W., and Fricklas, R.L., *Manual of Low-Slope Roof Systems, Fourth Edition, The McGraw-Hill Companies, Inc.,* New York, 2006, Table. 5.2, pg. 81

Commentary

This Commentary is not a part of this standard. It consists of explanatory and supplementary material designed to assist users in complying with the requirements. It is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at these requirements or to provide other clarifications. It therefore has not been processed in accordance with ANSI Essential Requirements, and may contain material that has not been subjected to public review or a consensus process. Thus it does not contain requirements necessary for conformance with the standard.

The sections of this Commentary are numbered to correspond to the sections of the NT-1 standard to which they refer. Since it is not necessary to have supplementary material for every section in the standard, there are gaps in the numbering of the Commentary.

C.2.3 Per the Nuclear Regulatory Commission (NRC) the film badge may contain two or three films of differing sensitivities, and it may also contain a filter that shields part of the film from certain types of radiation.

C.5.1.1 Rooftop access should not be permitted without adequate roof and roof deck condition data. Prior to or as part of the nondestructive nuclear evaluation, a physical roof survey is required to visually determine areas that are not safe for access by persons required to perform the survey. The survey must include, at a minimum, a physical interior deck and exterior roof survey. Use a checklist to ensure that all equipment, supplies, and documentation required for the survey are operational, packed, and transported to the job site.

C.5.2.2.1 Exact US to SI conversions are not required or included since consistency in the increments between x-y coordinates throughout the roof section is most important, and maintaining an even number of units of measure improves accuracy during layout in the field. If the roof section grid or x-y coordinates layout is based upon feet or meters, use feet or meters throughout.

C.5.2.2.6 Additional readings may be taken in areas producing elevated readings and at other locations as determined by the Survey Director to optimize the survey results.

C.6.1.1 The Survey Director may decide to extract more cores on each roof section as dictated by job conditions and the readings obtained.

a) Caution should be taken to not extract cores at extreme low and high end readings unless there are a number of other readings at similar levels (preferably in the immediate vicinity). The low and high reading locations sampled for testing should represent at least ten percent of equipment readings obtained.

b) If the "high" core sample exhibits free water, it may be advisable to extract another core sample of more moderate moisture content, as determined by a review of the equipment readings obtained.

C.6.2.1 Oven drying of extracted roof materials at temperatures exceeding those tolerated by the materials will affect results:

a) High temperatures may damage or otherwise modify the chemical composition of styrene-based foam insulations, gypsum-based products, lightweight concretes, and sample containers. It is recommended that a lower temperature (e.g., 110° F/43° C) be utilized for such materials.

b) Moisture contents of organic felt-based BUR membranes cannot be accurately determined by oven drying, since the low end volatiles are typically cooked off with the moisture. These membranes require the use of distillation methods, such as ASTM D 95.

C.7.1 A licensed architect, Professional Engineer (PE) or Registered Roof Consultant (RRC) who meets the requirements of a survey director and is experienced with both roofing and the nuclear survey equipment is preferred but not required provided the survey director meets the requirements otherwise stated.

C.7.4 It is often sufficient to utilize three or four color ranges to indicate the degree of moisture saturation. Red may be “failed,” Orange may be “high,” Yellow may be “low,” and White (or blank) could be “dry.” However, some definition of these terms should be provided in relation to the extrapolated moisture levels estimated within each roof. The intervals chosen may be modified depending on the assembly under evaluation and the type of insulation within the roof system.

C.9.1.9 An evaluation of the acceptability of moisture contents within installed roofing materials is a highly subjective matter, and should be conducted on the basis of experience, practicality, and judgment. Certain guidelines may be derived from data available pertaining to the thermal resistance ratio (TRR) of insulation materials. The thermal resistance ratio is equal to the wet thermal resistivity divided by the dry thermal resistivity. Some experts have established a TRR of 80% or higher as acceptable from the perspective of thermal performance. For some materials, while the thermal resistance is still considered acceptable, the suitability of the product with highly elevated moisture content above equilibrium may not be suitable as a substrate for roofing material applications as determined by a roof expert or roof material manufacturer.

C Table 3, 4, 5

Tables 3, 4, and 5 provide published values for materials available and commonly used in roofing assemblies at the time of the study to develop the data presented in the tables. Other materials may be encountered that are not listed. For those materials not listed the manufacturer of the material may be the only source for similar data and test result information. Exercise caution to assure all products are judged on the same basis since 80% TRR data may not be available for all products that may be encountered.