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# ANSI/GRHC/SPRI VR-1 2011 Procedure for Investigating Resistance to Root Penetration on Vegetative Roofs

Approved February 24, 2011

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### Disclaimer

This standard is 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 Purpose of this Standard

This standard is intended for testing the resistance of vegetative roof coverings to normal **root** and **rhizome** penetration.

## 2.0 Scope

The test described in this standard has been developed to evaluate the ability of a roofing material to resist normal **root** or **rhizome** penetration through a **root protection barrier**, or waterproofing layer. This test is based on the FLL "Procedure for Investigating Resistance to **Root** Penetration at Green Roof Sites." The FLL procedure was developed in Germany and is based on findings and testing experience of evaluations of various materials over a number of years. This test is intended to build on this experience and provide an equivalent evaluation protocol for North American test sites.

This procedure includes testing of vegetative roof **root** penetration barriers including all seams, edges and methods of attachment. This test standard excludes any lamination, i.e., a separate layer installed over the penetration barrier. The penetration barrier may be, but is not limited to, the waterproofing layer itself.

The test procedure only evaluates the top surface layer of the material to be tested where the membrane is composed of multiple layers of different materials. Materials included in the membrane system that are not exposed to **roots** are not evaluated by the test.

The test is intended to evaluate **root** resistance of environmentally stable physical barriers. Barriers based on chemical **root** inhibitors may be evaluated using this procedure; however, it should be noted that the procedure is not suitable for evaluating long-term chemical stability or long-term performance of these barriers.

The findings for any membrane or coating which has been tested shall not apply to plants with strong **rhizome** growth (e.g., bamboo or Chinese reeds varieties). When using such plants on top of a regular **root** penetration barrier, additional measures shall be taken and special care shall be specified by the designer of record.

The test procedure does not evaluate waterproofing suitability, environmental compatibility of, or long term stability of, any products tested (i.e., resistance to temperature, UV light, microbial decomposition, etc.). (See C2.0)

## 3.0 Definitions

The following definitions are used in this document:

### 3.1 Root Protection Barrier

Any membrane or coating intended to prevent penetration of **root** growth. It may also be a waterproofing layer.

### 3.2 Trial Container

A container to be used for the examination having certain minimum dimensions and equipped with the membrane or coating to be tested. (See 5.4).

### 3.3 Growth Media

An engineered formulation of inorganic and organic materials, including but not limited to, heat-expanded clays, slates, shales, aggregate, sand, perlite, vermiculite and organic material including, but not limited to, compost worm castings, coir, peat, and other organic material. The structure of this course shall offer good water and air management properties. It shall be given light basic fertilization for optimum **root** development of the test plants. (See 5.8) The **growth media** shall be in direct contact with the material to be tested.

### 3.4 Rhizomes and Roots

► Since the evaluation differentiates between **roots** and **rhizomes**, a reliable determination of these subterranean plant organs is indispensable. The following indications serve as a basis for the evaluation:

- ▶ **Rhizomes** expanding in the **growth media** show a regular thickness of approximately 079 in (2 mm) and few branches. They are divided into different sections with knots forming the boundaries between the sections. Around the knots inconspicuous small leaves surrounding the stem as well as thin **roots** have formed. In between the knots the couch grass **rhizomes** are hollow. (See 4.1 **Elymus repens** “Couch Grass” or “Quack Grass” and Figure 1)
- ▶ **Roots** vary in thickness and show several branches. Leaves never form, and **roots** are not hollow. (See 4.1 **Pyracantha coccinea**—“Orange Charmer” or Scarlet Firethorn” and Figure 1.)

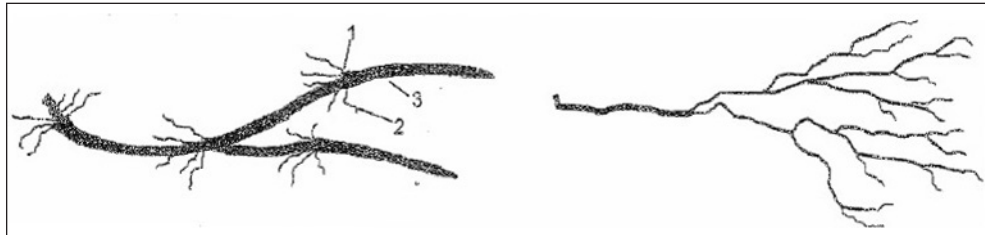


Figure 1: Schematic Representation Of Couch Grass **Rhizome** (Left) With Knots (1), **Roots** (2) And Leaves (3). “Orange Charmer” **Root** (Right).

#### 4.0 Test Plants

##### 4.1 Varieties (See C4.1)

Plants to be used shall be:

- ▶ **Pyracantha coccinea**, “Orange Charmer” or “scarlet firethorn”—a woody species capable of year round growth in a controlled environment greenhouse.
- ▶ **Elymus repens (AKA Agropyron repens)**, “Quack grass” or “couch grass”—a common weed species found on many roofs with a moderately aggressive rhizomatous growth habit.

##### 4.2 Sufficient Growth Performance of the Test Plants

The plants in the **trial containers** shall show an average growth performance of at least 80% (above ground biomass, i.e., height, diameter of the stem, leaf area, etc.) of the plants in the control containers during the investigation.

##### 4.3 Classification of Plant Growth

Plant growth shall be visually evaluated monthly with the following scale: Inadequate = <50% surface coverage, Adequate = 50–75% surface coverage, Good = >75% surface coverage. Within 3 months of the onset of the test, plant coverage of the medium surface shall be in excess of 60% of the surface, and there shall be evidence of new growth and plant **roots** shall be visible at the bottom of the control containers. Plant coverage shall remain dense (80% surface coverage and a dense mat of **roots** at the bottom of the control containers) throughout the remainder of the test procedure (Figure 2).

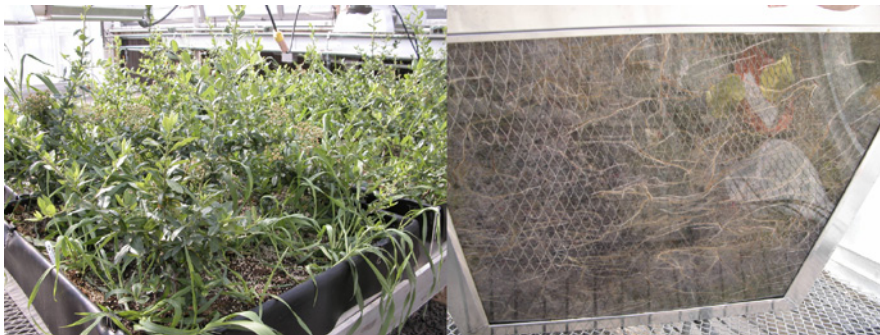


Figure 2: Healthy (good>75% coverage) plant growth in a **trial container** and dense **root** mat visible at the bottom of a control container.

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#### 4.4 Root Penetration

**Roots** have penetrated through the barrier or seams in the barrier material and are visible at the bottom of the **trial container** (Figure 3).

#### 4.5 Rhizome Penetration

**Rhizomes** have penetrated through the barrier or seams in the barrier material and are visible at the bottom of the **trial container** (Figure 3).

#### 4.6 Root Ingress and Surface Damage

**Roots** have grown into the surface or in the seam of the barrier and actively created cavities and have damaged the membrane or coating or seaming material. Not to be identified as **root** penetration but to be noted in the test documentation are:



Figure 3: **Root** penetration on backside of Membrane

▶ **Roots** that have grown into the surface or seam  $< 0.2$  in (5 mm) on membranes or coatings, which contain radicide substances (**root** protecting agents), since here any **root** banning effect can only act upon the **root** in the membrane or coating. To ensure a clear valuation, such membrane or coating shall be clearly coded as “radicide-containing” by the manufacturer before the investigation is carried out and limitations to the testing procedure based on environmental stability of the radicide will be noted in the report.

▶ **Roots** that have grown into the surface made of products composed of several layers (e.g., bituminous membrane with copper band inlays or single ply membranes with fabric inlays) provided that the layer taking over the function of an ingress and penetration barrier has not been damaged. To ensure a clear valuation this layer shall be clearly defined by the manufacturer before the investigation is carried out.

▶ **Roots** that have penetrated seam sealing compounds (without damaging the welded or otherwise sealed seam).

See Commentary C4.6 for definition of **root** adhesion.

### 5.0 Testing Procedure

#### 5.1 Description of the Procedure

The test shall be conducted in a climate-controlled greenhouse with environmental conditions maintained to promote continuous year-round growth of “Orange Charmer” and quack grass. The standard procedure is 2 years to ensure 24 months of active plant growth. Test periods longer than 24 months may be warranted to evaluate long-term stability of radicide materials. Plant growth procedures at individual test sites shall be modified based on local environmental conditions to ensure aggressive plant growth. Any modification from the standard procedure and the reason for the modification shall be noted in the test report.

Plants are installed in a commercial greenhouse or nursery **growth media** in the **trial containers**. (See 5.4) With dense planting and vigorous growth, moderate fertilization (see 5.8) and modest watering (see 5.9) the desired high **root** pressure will be obtained. At the Evaluation Stage, the **growth media** shall be removed from the container and the membrane or coating shall be examined to detect **root** or **rhizome** penetration or adhesion. (See 6.0) Control samples of any membrane or coating tested shall be saved and stored in a dark location at an average temperature of  $77^{\circ}\text{F} \pm 5^{\circ}\text{F}$  ( $25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ) for comparative examination at the end of the trial.

#### 5.2 Testing Location

A greenhouse equipped with heating and ventilation facilities shall be provided. The heating system shall be set to  $65 \pm 5^{\circ}\text{F}$  ( $18 \pm 3^{\circ}\text{C}$ ) during the daylight hours and  $60 \pm 5^{\circ}\text{F}$  ( $15 \pm 3^{\circ}\text{C}$ ) at night. Ventilation set points shall be  $75 \pm 5^{\circ}\text{F}$  ( $24 \pm 3^{\circ}\text{C}$ ) during the daylight hours and  $70 \pm 5^{\circ}\text{F}$  ( $21 \pm 3^{\circ}\text{C}$ ) at night. Maximum daylight or night temperature shall not exceed  $122 \pm 5^{\circ}\text{F}$  ( $50 \pm 3^{\circ}\text{C}$ )

or be above  $104 \pm 5^{\circ}\text{F}$  ( $40 \pm 3^{\circ}\text{C}$ ) for more than 1 hour. Minimum daylight or night temperature shall not be less than  $45 \pm 5^{\circ}\text{F}$  ( $7 \pm 3^{\circ}\text{C}$ ). Adequate space shall be provided to ensure that all containers can be accessed to be evaluated and maintained.

Supplemental lighting shall be used to augment natural light where winter day length or light intensity results in less than 6 moles per square meter per day monthly average irradiance between 400 and 700nm. Sufficient supplemental light shall be applied to bring the daily total irradiance to a minimum of 6 moles per square meter per day. This shall be accomplished by using indoor plant grow lights. Lights should use a minimum 7200°K full spectrum bulb which promotes overall plant growth. This can be obtained by high CRI fluorescent lamps or Metal Halide to better stimulate average North Sky. Lights shall be placed no more than 2–3 ft (0.6–0.9 m) from the plant material in the trial containers. Lights shall operate on 12 hour cycles until natural lighting conditions improve.

### 5.3 Test Duration

Following setup, the test shall run for a minimum of 24 months of equivalent plant growth.

### 5.4 Trial Containers

The internal dimensions of the containers used in the trial shall not be less than 32 in x 32 in x 10 in (800 mm x 800 mm x 250 mm). (See C5.4) **Trial containers** shall provide adequate space for membrane seaming to be used.

**Trial containers** shall be fitted with transparent bases (e.g., acrylic glass) so that **root** penetration can be detected even during the test phase without interfering with the **growth media**. (Figure 4).



Figure 4: Sample **trial container**. Note the interior metal fold to support the clear Plexiglas base.

For each **root** barrier to be tested, six **trial containers** shall be used. In addition, per experimental run—regardless of the number of membranes or coatings to be tested—three control containers (without any membrane or coating) shall be provided.

### 5.5 Protective Nonwoven Fabric

A nonwoven fabric made of synthetic fibers with a weight of approximately 200 g/m<sup>2</sup> shall be used in the bottom of the control containers. (See C5.5)

### 5.6 Membrane or Coating to be Tested

Test roof membranes **root** barriers, or waterproofing materials shall be supplied and installed in the **trial containers** per the manufacturer's specifications and shall contain several seams or joints as shown in Figure 6. Membrane shall be laid according to Section 5.12. Coatings shall be applied according to Section 5.13. The surface to be treated equals about 14 ft<sup>2</sup> (1.3 m<sup>2</sup>) per container, presenting the indicated minimum dimension 32 in x 32 in x 10 in (800 mm x 800 mm x 250 mm).

### 5.7 Growth Media

**Growth Media** shall be a greenhouse or nursery **growth media** composed onsite or a commercially available product. (See C5.7) When a commercial product is used the manufacturer and lot number shall be recorded. If composed onsite, the media formulation shall be recorded. EC and pH will be measured using a standard saturated paste method.

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## 5.8 Fertilizer

Fertilization by liquid feed or slow release fertilizer with complete macro and micro-nutrients shall be used to encourage plant and **root** growth. (See C5.8) Fertilizer shall be applied at the low or moderate rate recommended by the fertilizer manufacturer for containers of the size used to maximize plant growth. Formulations and quantities of fertilizer applied will be recorded and included in the final report. (See C5.8)

## 5.9 Irrigation

Plants shall be watered with good quality water suitable for greenhouse or nursery crop production. Plants shall be watered as needed based on local environmental conditions to maximize plant growth. Irrigation may be done by hand or by an automated system. In either case plants shall be allowed to dry between irrigation applications, and the media shall be thoroughly wetted with each irrigation application.

A tensiometer with a measuring range of 0–100 kilopascals (kPa) or centibars (cb) shall be used to monitor watering of the growing media per container.

## 5.10 Samples and Information Provided by the Manufacturer

To ensure a clear identification of the tested product, the following information shall be provided by the manufacturer before the test is started: product name, area of application, material description, material standards, thickness (without lamination), finish or structure, test certificates, year of manufacture, mounting or laying technique at the location of the investigation (overlapping, jointing techniques, jointing agents, type of seam sealing, covering strips over seams, special corner and angle joints), and admixture of biocides (e.g., **root** inhibitors) with details regarding the concentration of the substances.

For products consisting of several layers (e.g., bituminous membrane with copper band inlays or PVC membrane with polyester nonwoven fabric inlays), the manufacturer shall identify before the start of the investigation which layer is meant to take over the function of an ingress and penetration barrier.

## 5.11 Preparation and Installation of the Trial Container

**Trial containers** shall be prepared with the following layered superstructure (from bottom to top), Plexiglass **trial container** base, membrane or coating to be tested, **growth media**, planting.

After the installation of the membrane or coating (see 5.13) to be tested, the **trial containers** shall be flood tested for 12–24 hours to ensure that the waterproofing materials were installed properly.

The **growth media** shall be added to the **trial container** and compacted to a course depth of  $5.9 \pm .39$  in ( $150 \pm 10$  mm). (See C5.11)

Four pieces of *Pyracantha coccinea* (“Orange Chamer”) per **trial container** of 32 in x 32 in (800 mm x 800 mm) shall be planted equally spread over the entire surface (Figure 5). Also, .07 oz (2 g) of seeds of *Elymus repens* (quack grass) or 8–10 **rhizome** plugs shall be equally sown or planted uniformly in the growing media in each container.

If larger **trial containers** are used, the number of plants and the quantity of seeds shall be increased so that at least the same plant density is reached.

The tensiometer ceramic cell shall be placed into the **growth media** directly on top of the membrane or coating. Thus, measurements can be carried out in the lowest part of the **root** area. The tensiometer shall be placed in the center of the test box (Figure 5).

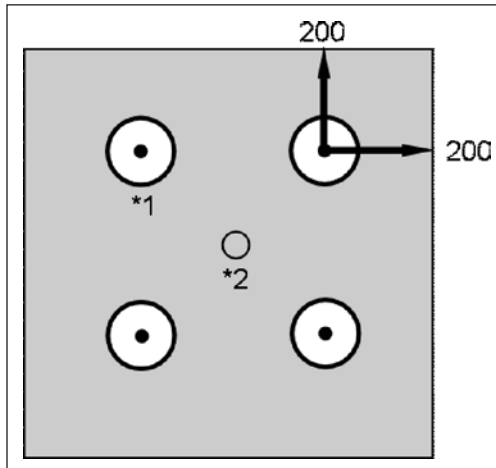


Figure 5: Arrangement of Plants (\*1) And Tensiometer (\*2) In the Growth Media in a Receptacle of 800 X 800 mm (Dimensions in mm)

### 5.12 Laying of Root Protection Membrane, Roof, and Damp-proof Lining

Cut out parts of the membrane or lining to be tested and lay them as required into the **trial containers**. Execute four seams at the corners where the walls meet, two seams along the base at the corners and one T-seam running along the middle. All membranes must be installed per manufacturer's published requirements. The membrane shall be brought up to the upper rim of the container walls (Figure 6).

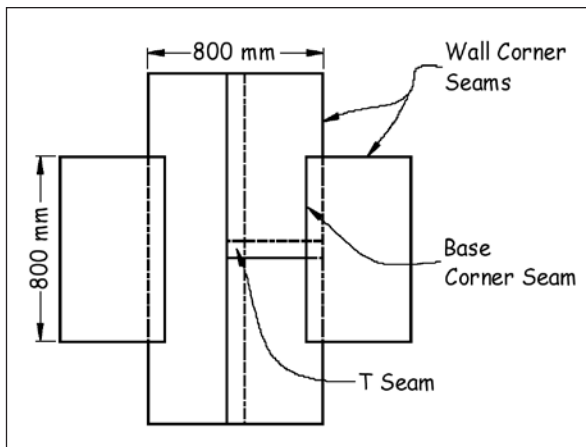


Figure 6: Layout of the Seams in the Membrane to Be Tested (Dimensions in mm)

### 5.13 Installation of Surface Coating under Investigation: Liquid Surface Treatment

The coating shall be brought up to the upper rims of the container walls. Seams or overlaps shall be included in the **trial container** installation for liquid applied materials equivalent to those described for sheet materials (5.12). If the material being tested has minimum and maximum recoat windows, seams shall be created both within and outside the recoat window following the manufacturers recommended procedures for each (Figure 7).

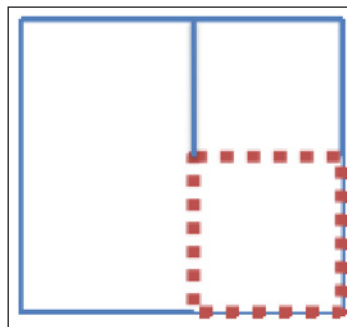


Figure 7: Seam or overlap pattern for liquid applied materials. Solid lines indicate seams and corners created within the recoat window. Dashed line indicates seams created outside the manufacturer's recommended recoat window.

#### 5.14 Preparation and Installation of the Three Control Receptacles

Control receptacles shall be prepared and installed as described in Sections 5.4 and 5.5.

#### 5.15 Care of the Plants During the Growth Period

The substrate moisture content shall be set according to the needs of the plants by means of top watering onto the **growth media**. The grower at the test site shall visually evaluate water requirements every 1–3 days and irrigate as needed. Sufficient water shall be applied at each irrigation to thoroughly wet the media. A tensiometer shall be used to assist in determining the requirements for irrigation.

To ensure a good germination and rooting of the plants in the first eight weeks after the greening process, irrigation shall commence as soon as the soil moisture tension drops below a value of 10 kPa (10 cb). Subsequent watering is applied only when the soil moisture tension falls below values between 30 and 40 kPa (cb).

Plant species other than those being evaluated should be removed.

Dead plants shall be replaced during the first 3 months of the investigation. If during the course of the investigation the losses in terms of plants account for more than 25% of the total plant number installed in more than 2 of the 6 replications the test shall be repeated.

Plants shall be pruned to aid in management or maintenance. Pruning shall be kept to a minimum because excessive pruning will limit **root** growth. Pruning shall be done equally to both test and control plants. (C5.15)

Insufficient quack grass coverage (< 40% of the surface is covered) shall be improved by up to two units of repeat seeding or by dividing existing plants or adding additional **rhizome** plugs in the first three months of the test.

In case of pest attacks or plant diseases threatening the survival of the plants under testing appropriate plant protection measures shall be carried out. Pesticide applications if necessary shall be kept to a minimum and the chemical class of the pesticides shall be carefully considered with the membrane manufacturer to avoid the use of materials that might interact with the roofing materials.

### 6.0 Evaluations

#### 6.1 Evaluation During Testing

In addition to observations of plant condition every 1–3 days for the purpose of irrigation management, a closer inspection of each **trial container** shall be made once a month. This observation shall include visual evaluation of plant cover, plant appearance, new growth, and **root** density at the bottom of the control containers. (See 4.2)

A formal evaluation of the transparent base of all 6 **trial containers** shall be conducted in intervals of 6 months to detect visible **roots** and **rhizomes** (i.e., successful **root** penetration). A digital photograph of each **trial container** (base and plants) and each control shall be taken during this evaluation.

If visible **root** penetration is discovered in any one of the **trial containers**, the trial shall be discontinued at the discretion of the manufacturer. (See 4.6)

Plant damage, such as deformations of the leaves or changes of leaf color, shall be noted.



## 6.2 Evaluation at the End of the Trial

Evaluation commences with a final monitoring of the growth performance of the plants. Plant above ground biomass for test and control plants shall be compared.

After the above ground biomass has been removed and evaluated the containers shall be turned upside down and the media and **root** mass removed. In a successful test the entire media mass will be completely bound together by **roots** and will come out of the test box as a single mass. **Root** density at the bottom of the containers shall be evaluated when the boxes are disassembled. **Root** density at the bottom of the **trial containers** shall be comparable to **root** density of the control containers as determined by visual inspection. Successful plant growth is indicated by a solid mat of **roots** at the bottom of the **trial containers**. **Root** density at the bottom of the **trial containers** of less than 80% observed in control containers indicates poor test conditions and the test should be repeated at the discretion of the manufacturer.

After plant and **root** evaluations, examine the membrane or surface coating for **root** and **rhizome** adhesion or penetration. Wash with garden hose using gentle pressure, any loose material should wash off. Evaluate any adhered material under a microscope for possible penetration. Examine remaining material to determine if **roots** have adhered to the surface. Any **roots** remaining after washing shall be examined with a microscope to determine if they are surface attached or have penetrated into the membrane. **Roots** or **rhizome** ingress and penetration into the membrane or coating shall be recorded.

### 6.2.1 Test Field Evaluation

If more than 50 **roots** or **rhizomes** per container are found to have penetrated into but not through the membrane or coating, the evaluation on penetration shall be performed only on a section of the tested material. In this case, the evaluation shall cover at least 2 ft<sup>2</sup> (0.2 m<sup>2</sup>) equivalent to about 20% of the membrane or coating covered with the substrate, and shall be performed in the area indicated in Figure 8. The penetration of **roots** or **rhizomes** into the field of the evaluation area shall be recorded.

### 6.2.2 Test Seam Evaluation

The penetration of **roots** or **rhizomes** into the overlap area of seams shall be recorded. Samples of the membrane or coating for retention purposes shall be taken to mirror the result of the investigation. The samples shall be compared to the control samples stored at the initial stage of the testing. (See 5.1)

### 6.2.3 Failure Criteria

A membrane or coating is deemed to have failed if a **root** or **rhizome** completely penetrates through the tested material.

## 6.3 Premature Test Termination

If in the course of the test evaluations visible penetrations of **roots** or **rhizomes** into the membrane or coating to be tested is identified the test shall be terminated. (See 4.6)

If during the test phase more than 25 % of the plants are lost, the investigation shall be started anew, i.e., new planting shall be carried out. At the same time, the growing media shall be replaced by a new mixture.

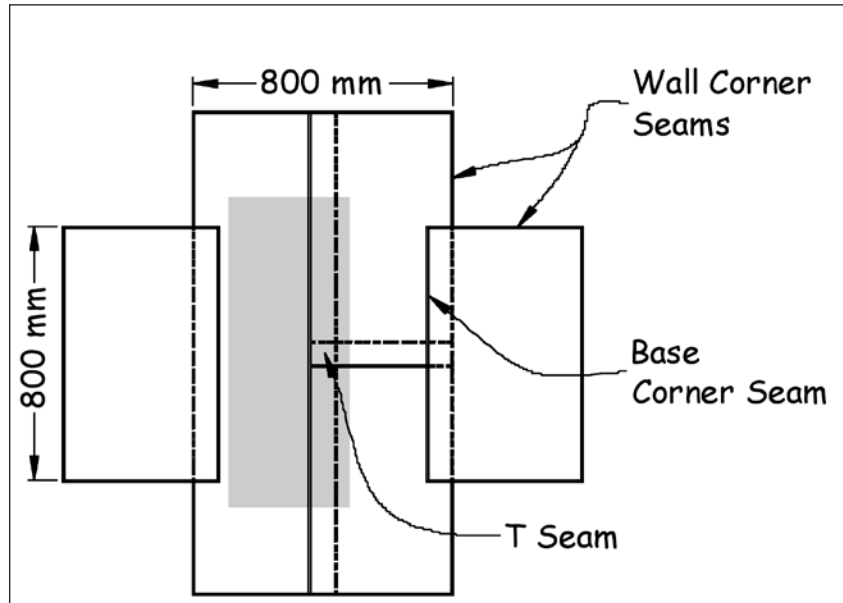


Figure 8: Evaluation Section of Penetrations into the Surface of a Membrane or Coating with > 50 Penetrations or Receptacle (Dimensions in mm)

#### 6.4 Test Report

Upon termination of the trial a complete test report about the test shall be prepared.

The report shall contain the following information:

- ▶ Details provided by the manufacturer in relation to the membrane under testing
- ▶ (See 5.10):
- ▶ Description of the preparation of the **trial containers**: and
- ▶ All evaluation results in accordance with Section 6.1, 6.2 and 6.5.

## Commentary

This Commentary is not a part of ANSI/SPRI VR-1 Investigating Resistance to **Root** Penetration on Vegetative Roofs. It is included as supplemental information.

This Commentary consists of explanatory and supplementary material designed to assist users in applying the recommended requirements. It is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at these requirements. The following wording shall be included in introduction to the Commentary: "The information contained in this Commentary is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, Commentary may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard."

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

- C2.0** The goal of this test procedure is to maximize **root** and **rhizome** growth in contact with the **root** resistant barrier or waterproofing membrane. The two moderately aggressive and vigorous plant species chosen represent a realistic threat to waterproofing integrity when well grown. Plant growth procedures described in this test are intended to maximize **root** and **rhizome** growth.
- C4.1** "Orange Charmer" is an ornamental plant which under greenhouse conditions shows an all year round **root** growth suitable for the test.
- Quack grass (*Elymus repens*) is an indigenous grass with slow-growing **rhizomes**, the settling of which can hardly be avoided on vegetative roofs, and which also grows sufficiently all year under the given testing conditions.
- C4.6** **Root** adhesion is defined as **roots** that stick to the surface of the material or imperfections in the surface of the material that are not easily washed off with a low pressure water stream. This may include **roots** that have entered surface air bubbles or craters in the surface of the material but not progressed beyond the limits of the surface imperfection. **Root** adhesion does not include **roots** that stick to the material because of surface erosion or other degradation of the material.
- C5.4** Larger containers may be used if the circumstances under which they are to be installed so require. For example, a larger **trial container** would be needed to evaluate seaming details as they would be installed in the field.
- C5.5** The material compatibility of the nonwoven fabric with the membrane or coating to be tested shall be ensured. The material demand comes to 7 ft 2 in (0.65 m<sup>2</sup>) per 32 in x 32 in (800 mm x 800 mm) **trial container**.
- C5.7** Examples of commercially available **growth media** are Premier Horticulture Pro-Mix BX, Quebec, or other equivalent media. The substrate will require about 88 L per receptacle (taking into account a substrate supply via plant earth-clumps).
- C5.8** An example of commercially available fertilizer is Osmacote Plus 15-9-12 with a release over 6 months.
- C5.11** This corresponds to a substrate volume of 88 L. for a receptacle of 32 in x 32 in (800 mm x 800 mm). It is advisable to place the receptacles on stands to facilitate **root** penetration checks in regular intervals. Keep a minimum distance of 0.4 m between and around the different receptacles.
- C5.15** Pruning is limited to side shoots if they are an obstacle to using walkways. Excessive pruning will limit **root** growth.

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