Comparison of Two Standards for Radon Mitigation in Existing Low-Rise Residential Buildings: ASTM's E 2121 and EPA's RMS

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Abstract

"Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings" is the title the American Society for Testing and Materials (ASTM) E 2121 consensus standard. Published in March 2001, E 2121 builds on and refines EPA's 1994 **"Radon Mitigation Standards"** (RMS). E 2121 and the RMS are compared; significant similarities and differences are identified. Cross references for the various sections of E 2121 and the RMS are provided.

Table of Contents

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Introduction

An Updated Radon Mitigation Standard Benefits the Radon Profession

The ASTM (The American Society for Testing and Materials) "Standard Practice for Installing Radon Mitigation Systems in Low-Rise Residential Buildings," E 2121, was accepted by the ASTM consensus process, in January 2001 and was published in March 2001. ASTM E 2121 refines and updates the US EPA "Radon Mitigation Standard" published in October 1993 and revised in April 1994.

A mitigation standard, updated and accepted, like E 2121, provides a common understanding of the practice of performing radon mitigation for radon professionals including mitigators, trainers, and regulators. E 2121 also provides a common understanding between radon professionals and their clients.

Persons buying a radon reduction system for their home are more confident, when they understand that the proposed mitigation system meets or exceeds the minimum requirements of an accepted standard. This client confidence translates into quicker client decisions, which in turn shortens the selling cycle for the mitigator.

E 2121 benefits the radon professional who wants to advertise that his/her product routinely exceeds basic minimum requirements. Should a mitigator choose to meet only the basic minimum requirements of an accepted standard, he/she can claim to provide a product that is superior to a competitor's, if that competitor's product meets a lesser standard or meets no standard at all.

The use of E 2121 can improve communications between a homeowner and a mitigator in many phases of the task of selling and installing a mitigation system. The mitigation standard is useful for describing procedures common to all mitigation projects, including building investigation, system installation, and post-mitigation performance testing.

Standards eliminate duplicate effort, and promote increased productivity. Purchasers of mitigation systems do not have to create a purchase specification, when they can reference an accepted standard. Providers of mitigation systems do not have to evaluate many different purchase specifications, if a well known standard has been referenced by the customer. Standards promote increased efficiency during mitigation system design. Standards, by defining requirements that are predictable, permit mitigation systems to be installed more efficiently.

A radon mitigation system designed and installed to conform to E 2121 should provide a durable radon reduction system, that provides acceptable radon reduction performance reliably for many years.

The use of E 2121 advances the objectives of regulators in protecting the public. Government officials, federal, state and local, who work as radiation control officials, health department officials, building inspectors, and building code officials, benefit from this updated radon mitigation standard.

If the government officials have no regulations, they can use this updated and accepted radon mitigation standard in their programs. If these officials are developing their own regulations, E 2121 can serve as a model. If the officials already have regulations, they can compare their regulations to another accepted standard, when they initiate periodic review for purposes of updating their regulations.

Many other stakeholders in the radon industry are touched by the use of E 2121. Radon testers, mitigation equipment suppliers and manufacturers, mitigation trainers, and the credentialing organizations for radon professionals, are served well by the availability of this updated and accepted radon mitigation standard.

Persons, from outside the radon industry, who work in occupations that support the conveyance of real estate, including home inspectors, benefit because E 2121 establishes clear minimum requirements for a radon reduction system. E 2121 provides a basic solution for reducing unacceptable radon concentrations in low rise residential buildings.

ASTM: The American Society for Testing and Materials

The American Society for Testing and Materials (ASTM), was organized in 1898 ASTM, headquartered at 100 Barr Harbor Drive, West Conshohocken, PA 19428, has approximately 32,000 members. ASTM publishes more than 11,000 standards in a 75-volume "Annual Book of ASTM Standards" which is also available on CD.

The purpose of ASTM is to provide a forum for the development and publication of voluntary consensus standards for materials, products, systems, and services that meet the needs of industry and government agencies by providing documents that can be used as a basis for manufacturing, procurement, and regulatory activities.

Currently 128 technical committees are developing standards for metals, paints, plastics, textiles, petroleum, construction, energy, the environment, consumer products, medical services and devices, computerized systems, electronics, and many other areas. Each technical committee is divided into smaller sections, subcommittees, and/or task groups.

E 2121 was developed in ASTM Task Group E06.41.03 chaired by Philip H. Anthes, and was submitted for acceptance to the ASTM consensus process.

The ASTM staff provides administrative support to the technical standards writing committees, which are composed of representatives of industry, government, academia, and others.

All research, testing, and data gathering is performed by members within their respective companies and organizations. No research or testing is performed at ASTM Headquarters. The committees are independent, pursuing standardization issues considered necessary by their members.

Membership in ASTM is unrestricted and limited only by the boundaries of a member's interest in a particular area of standardization.

Approximately 80 % of ASTM's income is derived from the sale of publications, primarily from the standards that the committees produce. Other income is derived from annual administrative fees, including membership fees.

Overview of ASTM E 2121-01

Standard Practice for Installing Radon Mitigation Systems in Low-Rise Residential Buildings

Radon mitigation is an activity for professionals. One mitigation system design does not fit all buildings, design choices are always made. Active soil depressurization radon mitigation designs always require that a pipe route be selected, and that fan and pipe sizes be specified. ASTM E 2121 defines the minimum requirements for the design and installation of certain radon mitigation systems. For the radon professional, E 2121 incorporates certain principles not previously referenced in a radon mitigation standard. Specifically, the ALARA principle from the practice of health physics and the use of a standard methodologies for calculating air flows in piping systems from the practice of industrial hygiene.

This ASTM Standard Practice incorporates guidance as well as regulatory/building code language. EPA's "Radon Mitigation Standard" (RMS) did the same. The sections that define the minimum requirements contain the word **shall**. Guidance sections usually contain the word **should**. The appendixes are guidance.

E 2121 builds on the RMS. The RMS served as the foundation for a young radon industry. E 2121 updates the RMS by reflecting both the advances in understanding of radon mitigation and the changes in the way radon mitigation is performed by professionals.

E 2121 recognizes that EPA has discontinued its Radon Proficiency Program in December of 1998 and other changes that have occurred since the publication of the RMS. E 2121 reflects current versions of referenced publications.

During the development of E 2121 the technical requirements of the RMS were reviewed. Technical and other changes were proposed, discussed, and balloted until a consensus was reached following ASTM procedures each step of the way.

E 2121 has an expanded scope and refines portions of the RMS. Since there are different radon fans available now, than there were in 1994, fan selection has become more complex. E 2121 provides a framework for more informed fan selection by including information about the active soil depressurization system's principles of operation, and guidance on pipe size selection. Also, because the need for multiple suction point systems is recognized, guidance on multi-suction point radon system piping is provided.

As mitigation practitioners have gained experience, they have recognized the need for new tools to solve more complex problems. The radon mitigator can benefit, if he/she understands something about the piping and air flow calculations of the industrial hygienist. E 2121 introduces this subject for those encountering more complex situations.

Active soil depressurization is now widely recognized to be better than other radon mitigation strategies; E 2121 acknowledges this fact.

E 2121 is beginning to approach mitigation in terms closer to those of the radiation protection professional whose goal is to reduce exposures to radiation to levels as low as reasonably achievable (ALARA). The ALARA concept for both installers and clients is introduced. Mitigation designs, which follow the radiation protection professionals' ALARA principle, require that radon vent stack discharges be directed upward and that the vent stack discharge point be above the edge of the roof and separated from openings into occupiable spaces. ALARA based work practices, which should reduce radon exposures to workers are also included in E 2121.

Appendixes provide a rational for the practice. The appendix concerning the principles of operation for ASD mitigation systems, was added to provide a perspective for E 2121. The appendix on fan and pipe size should help the practitioner to think about what enhances air flow and operating efficiency.

As the practice developed in the ASTM task group, there was a lot of discussion about how radon mitigation systems worked so a "Principles of Operation" for active soil depressurization systems was developed by the consensus process and is included in Appendix X2.

E 2121's Appendix X3 discusses certain aspects of pipe size, fan size and fan location, and for more information, refers the reader to "Industrial Ventilation: A Manual of Standard Practice," which has been used for more than 20 years, and is published by the American Conference of Governmental Industrial Hygienists.

Perspective on Six Areas of Dissimilarity

Many changes were introduced in ASTM E 2121. The background and rationale associated with six mitigation topics are presented here. This paper does not purport to provide a rationale for all of the differences between ASTM's E 2121 and EPA's RMS. The changes brought by E 2121 are sometimes more rigorous than the RMS and sometimes less rigorous. The six topics are:

1. **References to EPA's Radon Proficiency Program (RPP) do not appear in E 2121.**
2. **Chimney backdrafting tests are not required in E 2121.**
3. **The radon vent stack discharge orientation and location has been changed in E 2121.**
4. **Plugged fan cords are acceptable for use outdoors in E 2121.**
5. **Sealing requirements for slabs and membranes have changed in E 2121.**
6. **Multi-suction point system piping requirements have been added in E 2121.**

> Note: The complete texts, for the topics discussed, are found in EPA's RMS and ASTM's E 2121. The specific section/subsection numbers of this text are shown in square brackets. Example --- [Reference RMS X.X.X and/or E 2121 Y.Y.Y]

Area 1 References to EPA's Radon Proficiency Program (RPP) do not appear in E 2121 because EPA discontinued the RPP.

[Reference RMS 1.0, 3.0, 6.2, 6.3, 7.2, 7.3, 7.4, 7.6 18.1 through 18.5 and Appendix A]

Most of the RMS sections referring to the discontinued RPP, are about that program's administration and no longer apply. However, RMS subsection 7.6 is about a procedure for requesting approval for variations from certain mandatory language in the RMS. E 2121 needed to allow variation from certain mandatory language also. E 2121 could not use the procedures of the RMS. E 2121 has allowed for certain variations in a different way.

Mitigation systems installations, that vary from the RMS, are allowed if they are classified as "research on innovative techniques" and if prior approval is obtained from a state or a Regional EPA office, for the use of the "innovative mitigation technique". The states or EPA assign staff to evaluate proposals for radon mitigation system installations that do not comply with the RMS.

Because an ASTM standard practice may not direct a state or the EPA to approve or disapprove "research on innovative mitigation techniques", this feature was dropped from the language of E 2121. In its place, a provision was placed in E 2121 which allows variances from E 2121's requirements for pipe sizes and pipe configurations provided that the reasons for the variations are justified by system performance measurements and calculations, that are to be recorded and provided to the client.

EPA's requirement for the documentation of the "innovative mitigation technique" and how long it would take EPA to approve the proposed "innovative mitigation technique" was not published. The requirements for documentation under E 2121 are probably less onerous, and clearly a lot quicker. The breadth of the kinds of allowable "innovative mitigation techniques" has probably been reduced in E 2121. Today active soil depressurization (ASD) is widely accepted as the mitigation technique of choice, so the need for other "innovative mitigation techniques" has been reduced. E 2121 is primarily directed at implementation of the ASD mitigation strategy; E 2121 acknowledges certain ventilation mitigation techniques.

Area 2 The Chimney: Backdrafting Tests are not Required; Separation from Radon Vent Stack Discharge is Required in E 2121.

Short term backdrafting tests like the one required by the RMS have been found to be unreliable, because they failed to identify a problem when there was one, as well as falsely concluding that there was not a problem when there was one. A more complete explanation of this issue is provided in Exhibit 5. [Reference RMS 11.1 through 11.5 and E 2121 7.1.4]

It is well known that at certain times of the year a creosote smell may be detected in houses that have wood burning appliances. The creosote smell is believed to be carried into the house by air flowing down the chimney past creosote deposits. Because there is commonly air flow down chimneys, and because the guidance of radiation protection experts is to keep exposures to radiation as low as reasonably achievable (ALARA), E 2121 considers chimney discharge points to be openings into occupiable space and therefore requires that chimney discharge points and radon vent stack discharge points be separated. [Reference E 2121 7.3.2.9 (3)]

Area 3 The Radon Vent Stack Discharge Orientation and Location has been Changed in E 2121.

In E 2121 radon vent stack discharges must be vertical and aimed upward. Discharges must be located away from openings into occupiable space.

The discharge must be above the edge of the roof. A discharge above a line drawn between the eaves on the gable end of a house, allows the radon discharge to be directed along the side of a house. In such cases, the side of the house interferes with the dispersion of the discharge plume. Discharges with plumes directed downward or horizontally, do not direct radon discharge plumes away from openings into occupiable space as well as plumes that are directed upward. Standard stack designs for other hazardous gases do not direct discharge plumes up the sides of buildings, downward or horizontally.

There is no published EPA radon measurement protocol for determining the radon concentrations around a person near an open window. To evaluate such a situation, the measurement must be taken at the right place at the right time with the right equipment. Locating the discharge at a position above the roof reduces the risk of re-entrainment, thereby reducing the risk of radon exposures to humans, and is consistent with the practices for the discharge of other hazardous pollutants. Again, using the ALARA principle, used by health physicists, as guidance E 2121 requires that radon vent stack discharge points be located above the roof. [Reference RMS 14.2.8 and E 2121 7.3.2.9]

Area 4 Plugged Fan Cords are Acceptable for Use Outdoors in E 2121.

[Reference RMS 14.6.5 and 14.6.7 and E 2121 7.3.12.5 and 7.3.12.6]

The 1999 National Electric Code (NEC) allows the use of plugged flexible cords on appliances, indoors and outdoors. An example of an indoor plugged connection is the garbage disposer; an example of an outdoor connection is the swimming pool pump. Radon fans may also be connected with plugged cords inside or outside. If the radon fan produces 1/8 horsepower, a means of disconnection, within sight of the fan is required by the NEC. A plugged cord is an acceptable means of disconnection.

The RMS requires that fans installed outside be hard wired. E 2121 allows plugged cords on outdoor fans, because the NEC allows them and at least one state with radon regulations had examined this issue and allowed plugged cords on outdoor fans. There was a great deal of discussion in the task group about whether it was a good or a bad idea to install a radon fan with a plugged cord outdoors. The note of caution in the electrical section of E 2121 lists some of the reasons why a plugged cord used outside may not be such a good idea. On the other hand it is not always a bad idea. This note of caution is a clear example of a standard produced by a group trying to achieve consensus.

E 2121 attempts to offer guidance about when a disconnecting means is required by the NEC. Because radon fan horsepower (output) is not generally provided on radon fan labels, a conversion relating 1/8 horsepower output to the 93 watts (input) is shown, using the unstated assumption that the fan motor is 100% efficient for the purposes of safely determining whether a "disconnecting means" is required or not..

Because the assumption that the fan motor was 100% efficient, was not explicitly stated, it is now recognized that greater clarity could be achieved if the underlined words were added to subsection 7.3.12.5: "... rated at greater than 1/8 HP, (93 watts, assuming a 100% efficient fan motor) ...". In addition, for further clarification, a note could be added at the end of the subsection which reads:

Note 4—A radon fan label typically shows the electrical input power (watts) that the fan requires. Radon fan motor output (horsepower) is usually not found on the fan label. If a radon fan motor is 100% efficient, 93 watts input produces 1/8 horsepower output. If a fan motor is 50% efficient, 186 watts input produces a 1/8 horsepower output. To accurately convert from the known fan input (watts) to the unknown fan output (horsepower), the radon fan motor efficiency must be known.

Area 5 Sealing requirements for slabs have been relaxed; sealing requirements for membranes have been strengthened in E 2121.

E 2121 relaxes the sealing requirements for slabs, which are undeniably sealed better than membranes, and strengthens the requirement to seal membranes to enhance the performance of sub-membrane depressurization systems.

It is well known that air leaking through cracks and openings in slabs and at the floor-wall joints can sometimes reduce the effectiveness of sub-slab depressurization systems. Over the years, great care has been taken to require sealing at cracks and openings in slabs, walls, and floor- wall joints. Historically, the need to seal membranes has lacked emphasis.

Soil depressurization works because the gas permeable layer (of soil or aggregate) is sufficiently sealed (below it, above it, and at its edges) to become depressurized. This principle applies to soil (or aggregate) covered by slabs or membranes.

For a slab, cracks and openings through the slab and cracks and openings at the floor-wall joints require sufficient sealing. Likewise sufficient sealing is required at membrane seams and penetrations. Also, sealing is required at the membrane's edges to the structure's walls. Passive sub-membrane systems require even better sealing than active systems. It is generally agreed that passive radon systems, based on soil depressurization, should be capable of being activated.

Few people would disagree with the statement that a poured concrete slab inherently provides a better ground cover for preventing the flow of soil-gas into a structure than a membrane, which is usually loose laid sheets of plastic, overlapped 12 inches, but not attached to walls or membrane penetrations.

Whether to seal a slab or not depends on judgements about issues like compromised pressure field extension, noise, and backdrafting potential.

Careful sealing of ground covering membranes is required to achieve the same degree of sealing that is provided by a typical poured slab. Membranes are sealed for the same reasons that slabs are sealed, i.e. to enhance pressure field extension, to reduce noise, and to reduce backdrafting potential.

Sealing Floor Slabs and Foundation Walls:

The RMS requires that all cracks, in the floor slab or at the floor wall joint, be sealed. [Reference RMS 15.5.4]

E 2121 allows the mitigator to use judgement about sealing cracks in floor slabs and at the floor wall joint, but requires sealing of cracks and openings that materially effect the pressure field extension under the slab. [Reference E 2121 7.3.4.2] Subsection 7.3.4.2 would be clarified if it read:

> 7.3.4.2 It is sometimes appropriate to seal accessible openings and cracks with urethane caulk or equivalent material. Seal, if necessary, the cracks where the slab meets the foundation walls (the floor-wall joint), other openings and cracks found in slabs, in walls, around utility penetrations, and where channel or French drains have been installed. When the opening is greater than ½ in. (13 mm) in width, a foam backer rod or other comparable filler material may be inserted in the opening before application of the sealant.

Sealing Membranes:

The RMS does not require the sealing of membranes around interior piers and at the edges. [Reference RMS 14.5.6]

E 2121 requires more sealing of membranes at posts and other penetrations and at the edges to the extent practical. E 2121 requires drainage of a membrane where water could collect on it. [Reference E 2121 7.3.8.1]

Area 6 Certain Radon System Piping Requirements for Multi-suction Point Systems have been Added in E 2121.

The RMS does not Mention Multi-suction Point Depressurization Systems.

The RMS is silent on the requirements for multi-suction point systems. The RMS was written about soil depressurization systems with one suction point. Years ago, at a national radon meeting a state radon inspector criticized an active soil depressurization system because it had too many suction points. That inspector must have noticed that the RMS did not mention multi-suction point depressurization systems.

Without guidance from the RMS, multi-suction point systems have been installed, because they were needed a) for split level houses - where both slabs required mitigation, b) where low gas permeable soils required extra suction points to accomplish adequate pressure field extension, c) when sub-slab and sub-membrane depressurization mitigation strategies were required in the same structure, and d) other situations where it was desirable to utilize a single radon vent stack while employing two or more suction points. [Reference RMS 14.2.1 through RMS 14.2.8 and 15.2 and 15.3]

E 2121 Covers Multi-suction Point Systems.

E 2121 defines different parts of a radon mitigation system's piping. In E 2121 there are three kinds of radon system piping, 1) suction point pipes, 2) manifold pipes and 3) vent stack pipes. Certain basic relationships are established between the sizes of the vent stack and multiple suction point pipes. Terminology used for the various parts of the radon system piping is provided in Exhibit 6.

The RMS requires either 3 inch or 4 inch ID pipe and covers only single suction point systems. Under the guidance of the RMS the smallest suction point pipe allowed is 3 inches, which could be attached to a either a 3 inch or 4 inch vent stack. In the RMS there is no guidance about when to use to use a 3 inch or a 4 inch vent stack. ASD radon system pipe sizes in E 2121 depend, in part, on piping configurations. [Reference E 2121 7.3.2.1 through 7.3.2.9] The following configurations are addressed in E 2121:

> **ASD Using a Single Suction Point** E 2121 requires 3 inch minimum ID pipe for single suction point ASD systems. Smaller system piping diameters are allowed if they can be justified by field measurements and proper design. (See Custom ASD Piping Designs below.)
>
> **ASD Using Two or More Suction Points** When two or more suction points are required, E 2121 specifies a 4 inch minimum vent stack ID. The reasoning is: For low flow situations, a 4 inch vent stack never degrades the performance of an ASD system; for high flow situations a 3 inch vent stack can, by restricting air flow, degrade an ASD system's performance.
>
> Smaller vent stack pipe diameters are allowed if they can be justified by field measurements and proper design. (See Custom ASD Piping Designs below.)
>
> **ASD Using Three or More Suction Points** E 2121 requires 3 inch ID or larger suction point pipe and 4 inch ID or larger vent stack pipe for mitigation systems requiring three or more suction points. E 2121 recommends that systems with three or more suction points be designed using field data and formulas, found in a manual of standard practice for duct design, such as "Industrial Ventilation: A Manual of Standard Practice, 24th Edition" available from the American Conference of Governmental Industrial Hygienists.

ASD Manifolds for Combining Suction Points Manifold piping used to connect suction points to the vent stack. The minimum manifold pipe ID for suction point connections is 3 inches. Where the manifold connects to the vent stack, the minimum manifold pipe ID is 4 inches. The manifold pipes' diameters must stay the same or increase - never decrease as air flows through them, toward the vent stack.

The manifold for an ASD system, with two 3 inch ID suction points, would be built by connecting each 3 inch ID suction point (using 3 inch ID pipe) to a 4 inch ID "air receiver" pipe. The 3 inch ID suction points must not be connected together before they are attached to the 4 inch ID "air receiver" pipe. The 4 inch ID "air receiver" pipe of the manifold is then connected to a 4 inch minimum ID vent stack.

Custom ASD Piping Designs E 2121 allows vent stacks for multipoint ASD systems that are less than 4 inches ID, if they can be justified by field measurement and proper design. The same is true for suction points that are less than 3 inches ID. Pipes with cross sections, other than round, may also be used, if justified by field measurements and proper design.

The justification of the custom design must be based on field measurements and calculations using air velocity, static pressure, and the quantity of air flowing per unit of time (example: cubic feet per minute) at each suction point, after each merge in the manifold, and in the vent stack. Calculations must be made using formulas found in "Industrial Ventilation: A Manual of Standard Practice, 24th Edition" available from the American Conference of Governmental Industrial Hygienists or an equivalent publication.

The field data and calculations used to justify the custom design must be recorded and provided to the client in the form of a written report.

Summary of Similarities between EPA RMS and ASTM E 2121-01

Items appear in no particular order.

1. Similar document arrangement and content is demonstrated by comparing the contents of the RMS with the outline of E 2121. E 2121 is clearly derived from the RMS. See Exhibits 1, 2, and 3, the "Document Cross Reference."

2. Similar radon mitigation system installation topics are found in the RMS and E 2121, as is apparent from the comparison of subsection topic names. It is clear that E 2121 is rooted in the RMS. See Exhibit 4, the "System Installation Cross Reference."

3. The purpose of the RMS and E 2121 is the same. The intended readers are the same, i.e. radon mitigation contractors, state and/or local officials, certification or licensure programs, and consumers seeking quality mitigation service.

4. E 2121 and the RMS reference the same EPA and other government documents, in most cases.

5. The mandatory provisions of the RMS and E 2121 are prefaced by the word "shall"; the provisions that are good practice, but are not mandatory, are prefaced by the terms "should" or "recommended." Persons familiar with the RMS should recognize the mandatory and non-mandatory provisions of E 2121.

6. Pipe size and material is the same in both the RMS and E 2121 for single suction point ASD systems, which is what the RMS covers. However, E 2121 requires that written justification for the use different pipe materials, sizes, and shapes be provided to the client; the RMS requires prior government approval, before the use of variations from its requirements.

7. The requirements for the location of heat recovery ventilation ports, attached to the building's interior or exterior, and whether used for supply or exhaust, is the same in both the RMS and E 2121 .

8. Diagnostic tests are encouraged but not mandated in both the RMS and E 2121.

9. Post-mitigation testing is required by both the RMS and E 2121, though the approaches are different.

10. Mitigation of radon in water is not covered by either the RMS or E 2121.

Summary of Differences between EPA RMS and ASTM E 2121-01

Items appear in no particular order.

1. Language relating to business procedures including contract content does not appear in E 2121. For example, a likeness of Appendix A of the RMS - The "Mitigation Project Record" does not appear in E 2121. E 2121 is more concerned with the technical requirements of mitigation installation, than specifying business practice.

2 Language that pertains to the EPA's RPP program is not in E 2121.

3 The citations for reference documents have been updated to reflect current revisions. For example, E 2121 cites the July 2000 edition of EPA's "Home Buyers and Sellers Guide".

4. New terms have been defined in E 2121.
A. "Occupiable spaces" have been defined in the ASTM Terminology section. "3.2.14 *occupiable spaces, n* — for purposes of this practice, are areas of buildings where human beings spend, or could spend time on a regular or occasional basis." © by ASTM Usage examples include:
    1) Elevated concentrations of radon and radon progeny should be reduced in "occupiable space",
    2) The discharge point of radon vent stacks is separated from openings into "occupiable space",
    3) Chimney discharge points are considered to be openings into "occupiable space."
B. Terminology for "Radon System Piping" has been introduced. Radon system piping has three components:
    1) "suction point piping",
    2) "manifold piping", and
    3) "vent stack piping".
(See Exhibit 6 for radon systems piping terminology used in E 2121.)

5 In E 2121 the stated goal, for building occupants and radon mitigation workers, is to reduce radon exposures, during and after mitigation system installation, to levels which are "As Low Reasonably Achievable," (ALARA).

6. Three Appendixes are included in E 2121.
A. The "Principles of Operation" of an active soil depressurization system,
B. "Radon System Piping and Fan Sizes", and
C. A table called "Active (Fan-Powered) Mitigation Methods" The table indexes the seven covered mitigation methods to their applicable sections in E 2121 section 7, the "Standard Practices for Radon Mitigation," and their definitions in the section 3, called "Terminology."

7. E 2121 does not specify the horizontal spacing of radon system piping supports. E 2121 requires that the pipe be supported.

8. E 2121 requires that the soil gas discharge from the radon vent stack pipe must be "upward", "vertical", and "above the edge of the roof." The requirements for the separation of the discharge point from openings into "occupiable space" has been specified.

9. The electrical section of E 2121 allows exterior plugged cords on fans, in order to achieve consistency with the 1999 National Electrical Code. However, with this change, there is a cautionary note about using the option, which includes a warning about children playing with an exterior plugged cord.

10. The backdrafting test is not required in E 2121. Since 1994 when the backdrafting test requirement was added to the RMS it has been determined that short term backdrafting tests, of the kind required by the RMS, are not reliable. Radon mitigators, because they are not usually licenced and/or certified combustion appliance specialists, and because there is no reliable short term backdrafting test procedure available to them, cannot be expected to determine if a backdrafting condition does or does not exist. See Exhibit 5 for the rationale used for this change.

11. If a mitigator suspects that a backdrafting issue could exist, E 2121 advises the mitigator to recommend to the building owner that the combustion appliances and associated equipment should be inspected for compliance with applicable code and repaired if necessary. See Exhibit 5.

12. E 2121 places restrictions on the use of the crawlspace depressurization mitigation strategy. These restrictions apply especially to crawlspaces containing combustion appliances and to crawlspaces abutting basements that contain combustion appliances.

13. E 2121, explicitly states that it applies to existing residential buildings, and recognizes that another standard, for new residential buildings, does or could exist. The RMS document does not explicitly state whether it applies to new construction or not; but it is clearly intended for existing buildings and not buildings under construction.

    E 2121 speculates that new home building contractors will follow an accepted standard for the installation of passive radon reduction systems and the activation of these systems. E 2121 recognizes that new home builders should be able to correct deficiencies, including radon problems, in their buildings, soon after they are discovered. A reasonable time for accomplishing these repairs is one year, which might be the warranty period. After a period of one year, from initial occupancy or sale, has lapsed, E 2121 would apply to the repair or activation of a radon mitigation system in a new home.

It is envisioned that E 2121, not a new construction standard, would apply whenever a person, other than the new home builder or his/her employee, is retained to complete or repair a radon mitigation system in a new home.

14. The definition of a contractor has been expanded to cover all persons who do radon mitigation. So when E 2121 says the contractor shall do something, the employee of an owner or a plumber is not exempted. E 2121 applies to all types of radon mitigation work, whether the person doing the work is certified or not.

15. E 2121 has updated worker health and safety requirements.

16. E 2121 has more specific requirements about pipe sizes and how multi-suction point ASD piping is to be connected. Exceptions are allowed based on certain field/diagnostic measurements and calculations. The justification for the variance must be written and must include the data collected and the calculations performed. A copy of the justification must be provided to the client.

17. E 2121 leaves decisions about where to seal slabs to the mitigator. Such sealing is no longer routinely required. Guidance is provided about when slab and floor-wall joint sealing should be undertaken.

18. Suction pit requirements have been expanded by specifying the minimum depth excavation required directly below the suction point. E 2121 also gives guidance on use of much larger suction pits.

19. E 2121 provides alternatives for providing relief from excess surface water, when a sump pit must be sealed with a cover.

20. The primary radon mitigation system monitor, required by E 2121, must be air flow or pressure operated. Other monitor types may be used in conjunction with the primary monitors.

21. E 2121 requires deliberate attempts to obtain post-mitigation test results. The contractor may rely on radon tests performed a) by a building owner/occupant, b) a certified testing company, or c) tests obtained by a relocation company. The contractor is not to perform the radon test, but may supply the devices used for the test.

22. E 2121 favors active soil depressurization (ASD) strategies over ventilation strategies. ASD is generally more effective. Five of the active mitigation methods are based on ASD, and two on ventilation, namely heat recovery ventilation and crawl space depressurization. E 2121 embraces the concept that it is better to keep radon out of a structure than to dilute it by ventilation after it is present.

23. E 2121 requires that uncovered membranes, used with active soil depressurization systems, be sealed along their seams, be sealed at their edges to the walls of the structure, and be sealed all around membrane penetrations.

24. Isolation (i.e. the construction of interior partitions with gasketed doors to contain radon in sealing crawlspaces) as a mitigation strategy does not appear in E 2121. Using conventional building materials and construction practices, the isolation strategy has not prevented radon from passing from crawlspaces, through floors and partitions into occupiable spaces above and beside crawlspaces.

25. E 2121 considers radon mitigation to be an ordinary repair. However, E 2121 does require that the applicable laws and regulations of all jurisdictions be followed.

26. E 2121 uses both English and SI units.

27. E 2121 does not provide for "research on innovative mitigation techniques" because an ASTM standard can not mandate government oversight of such work.

Side by Side Comparison - Similar Sections: Meaning is Consistent

This side by side arrangement is intended to permit close comparison of certain corresponding sections of the RMS and E 2121. Examples of similar and dissimilar sections are provided. Six side by side comparisons are presented. Three comparisons are examples of similarity, and three are examples of dissimilarity. The sections chosen for comparison were arbitrarily selected.

Similar Sections, Example 1. -- The RMS section titled "Scope" and E 2121's section titled "Summary of Practice" deliver the same message but the wording is different. The sections of each document are shown verbatim.

RMS	E 2121
4.0 Scope The requirements addressed in the RMS include the following categories of contractor activity: General Practices, Building Investigation, Worker Health and Safety, Systems Design, Systems Installation, Materials, Monitors and Labeling, Post-Mitigation Testing, and Contracts and Documentation.	**4. Summary of Practice** © by ASTM 4.1 This practice describes methods for mitigating elevated levels of radon in existing attached and detached residential buildings three stories or less in height. 4.2 The mitigation process is described in terms of the categories of activity associated with radon mitigation and includes: general practices, building investigation, systems design, systems installation, materials, monitors and labeling, post-mitigation testing, and contracts and documentation. 4.3 The systems installation category contains subsections describing the specific requirements applicable to each of the components of radon mitigation systems, for example, radon system piping, radon fans, sealing, electrical, etc.

Side by Side Comparisons - Similar Sections: Meaning is Consistent (continued)

Similar Sections, Example 2. -- The RMS section titled "Limitations" and E 2121's section titled "Significance of Use" serve the same purpose but the wording is different. The sections of each document are shown verbatim.

RMS	E 2121
7.0 Limitations 7.1 Although the provisions of the RMS have been carefully reviewed for potential conflicts with other regulatory requirements, adherence to the RMS does not guarantee compliance with the applicable codes or regulations of any other Federal, state, or local agency having jurisdiction. 7.2 Where discrepancies exist between provisions of the RMS and local codes or regulations, local codes shall take precedence. However, where compliance with local codes necessitates a deviation from the RMS, EPA recommends that RPP listed Mitigation Service Providers (mitigation contractors) report the deviation in writing to the appropriate EPA Regional Office and the appropriate state regulatory official within 30 days. It should be noted that EPA is not requiring the reporting that is recommended in this paragraph. States with radon mitigation contractor certification programs may require that contractors give prior notification of their intent to deviate from the RMS for research or other purposes. 7.3 The RMS is not intended to be used as a design manual, and compliance with its provisions will not guarantee reduction of indoor radon concentrations to any specific level. 7.4 The RMS shall not apply to radon mitigation systems installed prior to its effective date, except when a previously installed system is altered. "Altering" radon mitigation systems does not include	**5. Significance and Use** © by ASTM 5.1 The purpose of the methods, systems, and designs described is this practice is to reduce radiation exposures for occupants of residential buildings caused by radon and its progeny. The goal of mitigation is to maintain reduced radon concentrations in occupiable areas of buildings at levels as low as reasonably achievable. This practice includes sections on reducing radiation exposure caused by radon and its progeny for workers who install and repair radon mitigation systems. The goal for workers is to reduce exposures to radon and its progeny to levels as low as reasonably achievable. 5.2 The methods, systems, designs, and materials described here have been shown to have a high probability of success in mitigating radon in attached and detached residential buildings, three stories or less in height (see EPA "Radon Reduction Techniques for Existing Detached Houses, Technical Guidance (Third Edition) for Active Soil Depressurization Systems,"). Application of these methods does not, however, guarantee reduction of radon levels below any specific level, since performance will vary with site conditions, construction characteristics, weather, and building operation. 5.3 When applying this practice, contractors also shall conform to all applicable local, state, and federal regulations, and laws pertaining to residential building construction, remodeling, and improvement.

Similar Sections, Example 2. (continued)

activities such as replacing worn out equipment, or providing new filters, while leaving the remainder of the system unchanged. Mitigation systems installed prior to the effective date of the RMS should be in compliance with the requirements in force at that time (i.e. EPA Interim Radon Mitigation Standards, December 15, 1991, as amended by the Addendum on Backdrafting of October 1, 1992). If a radon mitigation system is found that does not comply with current standards, contractors should recommend to clients that the system be upgraded or altered to meet current standards. 7.5 Because of the wide variation in building design, size, operation and use, the RMS does not include detailed guidance on how to select the most appropriate mitigation strategy for a given building. That guidance is provided in the documents referenced in paragraphs 8.1, 8.2, and 8.3. 7.6 The provisions of the RMS are limited to proven technologies and methods. Publication of this standard is not intended, however, to inhibit research and evaluation of other innovative radon mitigation techniques. When such research is conducted, a performance standard shall be applied, i.e., post-mitigation radon levels shall be at or below EPA's action level (currently 4 pCi/L), and the systems design criteria in paragraph 13.0 shall be applied. Contractors who expect to deviate from proven radon mitigation technologies and methods (as defined in the RMS and other EPA references in Section 8.0) for purposes of research on innovative mitigation techniques, shall obtain prior approval from	

Side by Side Comparisons - Similar Sections: Meaning is Consistent (continued)

Similar Sections, Example 2. (continued)

state regulatory offices, document the non-standard techniques, and inform the client of the deviation from standard procedures. In cases where radon mitigation is not regulated by the state, contractors shall obtain prior approval from a Regional EPA office. 7.7 At this time, the RMS does not include standards for installing systems to mitigate radon in water. However, EPA is currently developing a standard that will regulate radon levels in domestic water supplies. Following publication of that standard, the RMS may be revised, as appropriate, to include standards for installation of systems that are effective in reducing radon levels in water.	

Side by Side Comparisons - Similar Sections: Meaning is Consistent (continued)

Similar Sections, Example 3. - The RMS section titled "Worker Health and Safety" and E 2121's section titled "Safety Hazards" serve the same purpose but the wording is different. The sections of each document are shown verbatim.

RMS	E 2121
12.0 Worker Health and Safety 12.1 Contractors shall comply with all OSHA, state and local standards or regulations relating to worker safety and occupational radon exposure. Applicable references in the Code of Federal Regulations and NIOSH publications are listed in paragraphs 8.12, 8.13, and 8.14. 12.2 In addition to the OSHA and NIOSH standards, the following requirements that are specifically or uniquely applicable for the safety and protection of radon mitigation workers shall be met: *(The above is followed by a list of 10 items.)*	**6. Safety Hazards** © by ASTM 6.1 Contractors shall comply with all OSHA, state and local standards or regulations relating to worker safety and occupational radon exposure. Applicable references in the Code of Federal Regulations include those in 2.2. Contractors also shall follow occupational radon guidance in 2.2. 6.2 In addition to OSHA standards and NIOSH recommendations, the following requirements specifically applicable to the safety and protection of radon mitigation workers shall be met: *(The above is followed by a list of 8 items.)*

Side by Side Comparisons - Dissimilar Sections: Meaning is Not Consistent

Dissimilar Sections, Example 1. -- The RMS subsection 14.5.8 about crawlspaces depressurization and E 2121's subsection 7.3.10 titled "Crawlspace Depressurization" have different meanings. The sections of each document are shown verbatim.

RMS	E 2121
14.5.8 When crawlspace depressurization is used for radon mitigation, openings and cracks in floors above the crawl-space which would permit conditioned air to pass out of the living spaces of the building, shall be identified, closed, and sealed. Sealing of openings around hydronic heat or steam pipe penetrations shall be done using non-combustible materials. Openings or cracks that are determined to be inaccessible or beyond the ability of the contractor to seal shall be disclosed to the client and included in the documentation.	7.3.10 ©byASTM Crawlspace Depressurization (CSD) -- Crawlspace depressurization is usually not the first choice radon mitigation method for crawlspaces because of its greater potential for hazardous failure, that is, backdrafting, and the probability of a high energy loss associated with its operation during the colder and hotter months. See Henschel, D. B.(1992) "Indoor Radon Reduction in Crawl-space Houses: a Review of Alternative Approaches", Indoor Air 2 (2) 272-278.[9] Sub-slab and submembrane depressurization are thc crawlspace mitigation methods that should be used whenever possible.

Side by Side Comparisons - Dissimilar Sections: Meaning is Not Consistent (continued)

Dissimilar Sections, Example 2. -- The RMS subsection 14.5.7 about combination foundations and E 2121's subsection 7.3.11 titled "Combination Foundations" have different meanings. The sections of each document are shown verbatim.

RMS	**E 2121**
14.5.7 In combination basement/crawlspace foundations, where the crawlspace has been confirmed as a source of radon entry, access doors and other openings between the basement and the adjacent crawlspace shall be closed and sealed. Access doors required by code shall be fitted with air tight gaskets and a means of positive closure, but shall not be permanently sealed. In cases where both the basement and the adjacent crawlspace areas are being mitigated with active SSD and SMD systems, sealing of the openings between those areas is not required.	7.3.11 Combination Foundations: © by ASTM 7.3.11.1 Buildings with elevated radon levels may have more than one foundation type. Mitigation may be required in parts of the building involving one, or more foundation types. Foundation types include slab-on-grade, basement, and crawl-space. Isolation of foundation spaces using barriers intended to keep radon from passing, for example, from the crawlspacc to the basement or vise versa are not recommended, because walls built using available building trade techniques, usually do not accomplish their isolation objective. In addition, if the purpose of the isolation is to seal off the crawlspace to enable crawlspace depressurization, it is not recommended. Crawl-space depressurization is usually not the first choice radon mitigation method for crawlspaces because of its greater potential for hazardous failure, that is, backdrafting, and the probability of a high energy loss associated with its operation during the colder and hotter months. Sub-slab and submembrane depressurization are the crawlspace mitigation methods that should be used whenever possible.

Side by Side Comparisons - Dissimilar Sections: Meaning is Not Consistent (continued)

Dissimilar Sections, Example 3. -- The RMS subsection 14.6.5 and E 2121 subsection 7.3.12.6 is about wiring of fan motors located outdoors. The sections of each document are shown verbatim.

RMS	E 2121
14.6.5 Radon mitigation fans installed on the exterior of buildings shall be hard-wired into an electrical circuit. Plugged fans shall not be used outdoors.	7.3.12.6 © by ASTM Flexible plugged cords, properly rated for electrical capacity and weather, may be used on radon fans inside or outside the building. These flexible plugged cords may also serve as a disconnecting means inside or outside the building. Radon fans, cords, plugs, receptacles, receptacle enclosures, switches, switch enclosures, etc. intended for outside use must have a weatherproof and unattended use rating, and are different than what is generally used inside the building. See "1999 National Electrical Code® Handbook, Eighth Edition." Note 4 -- **Caution:** A hard-wired electrical connection (with a disconnect switch) may be a preferable alternative to a flexible plugged cord connection for radon fans installed outdoors. There are safety issues and other disadvantages to flexible plugged cords being installed outdoors. Children may play with the outdoor cord or receptacle. Because the protection of wires in an outdoor plugged flexible cord radon fan installation may not equal that of a bard wired outdoor installation, the wiring may be subjected to greater risk of accidental damage. The outside flexible plugged cord, which may be located where access to it is not easily controlled, can be unplugged to free the receptacle for other purposes, and the radon fan may not be plugged in again.

Recent Participation during the Development of E 2121

During the ten years while ASTM E 2121 was developing, many people worked on the standard. All these people have made contributions in their way. But the last meeting of the task group, before E 2121 was voted into being is noteworthy.

The meeting was held on Friday, October 20th, the day before the 2000 International Radon Symposium was to begin in Brookfield, Wisconsin to encourage wide participation. It should be pointed out that all ASTM task group meetings are open to ASTM members and non-members alike.

The meeting had been advertised in the AARST newsletter that was mailed to all AARST members. Certain state radon officials were also invited to the meeting by letter. ASTM announced the meeting to all E 06 members, and by a special mailing to Dick Morris of the National Association of Home Builders (NAHB), who notified ASTM headquarters that he was not able to attend the meeting.

The purpose of the task group meeting was to review the working document that is now E 2121. NAHB opposed the document and had voted against adopting the document for ten reasons. There were no other negative votes. It was important to be sure that the document we had was "good enough" to present to ASTM for adoption.

A poll of the task group members was taken after eight hours of discussion when all of NAHB's objections and all other issues that any meeting participant wished to introduce had been discussed. The poll was taken on the question: "Do you feel that this document should not be adopted?" Each of the ten meeting members was asked the same question. Some meeting attendees stated that there were things about the standard that they would like to change, but all ten agreed that the document was good enough to present to ASTM for acceptance.

The document was presented to ASTM and was formally accepted and designated E 2121 on January 10, 2001.

The following are the ten persons who attended and participated at the October 10, 2000 meeting in Wisconsin.

Federal Government, Radon Official
- Mr. Eugene Fisher, US Environmental Protection Agency Indoor Environments Division

State Government, Radon Officials
- Mr. William Bell, Commonwealth of Massachusetts
- Mr. N. Michael Gilley, State of Florida

State Government Radon Officials (continued)

Mr. Michael Pyles, Commonwealth of Pennsylvania
Mr. Robert Stilwell, State of Maine
Mr. Matt Young, State of Ohio

Radon Industry Practitioners

Mr. Gary Hodgden, Radon Tester, Mitigation Contractor, Home Inspector, Kansas
Dr. Elean Robson PhD, Radon Tester, Mitigation Contractor, Indiana
Mr. Philip Noack, Mitigation Contractor, Michigan

ASTM E06.41.03 Task Group Chairman

Mr. Philip H. Anthes, Radon Mitigation Consultant, Massachusetts

Acknowledgments

Mr. Philip Anthes wishes to thank those who have been exceptionally supportive of the effort to achieve consensus on ASTM E 2121:

Mr. David Murane, for his perseverence as he served for the first seven years as technical contact/author of what is now E 2121.

Dr. Elean Robson, who has attended every ASTM Task Group meeting on E 2121 in my memory. Dr. Robson was a thoughtfully contributor at every meeting.

Mr. Gene Fisher, for his efforts as long time advisor to Mr. Murane and me, for his work as technical contact/author after Mr. David Murane retired, and for being an invaluable resource to me over the last few years, while I served as E 2121's technical contact/author.

Mr. William Bell who encouraged me to get into the radon field 12 years ago and has always supported and advised me. Mr. Bell was especially helpful in this effort because he brought together his colleagues from other states to participate and comment on the standard as it developed over the last two years. Mr. Bell has been keenly interested in the development of E 2121 and has been a major contributor to its technical content.

Exhibit 1

Outline
of
Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings

ASTM Designation: E 2121-01 (Published March 2001)

1. Scope
2. Referenced Documents
3. Terminology
4. Summary of Practice
5. Significance and Use
6. Safety Hazards
7. Standard Practices for Radon Mitigation

7.1 General Practices:
7.2 Systems Design:
7.3 System Installation:
7.4 Materials:
7.5 Monitors and Labeling:
7.6 Post-Mitigation Testing:
7.7 Documentation:

8. Keywords

Appendixes
(Nonmandatory Information)

X1. Active (Fan-Powered) Radon Mitigation Methods
X2. Active Soil Depressurization (ASD) Principles of Operation
X3. Radon System Pipe Size and Radon Fan Size and Location for Soil Depressurization Radon Reduction Systems

Exhibit 2

Outline
of
EPA Radon Mitigation Standards (RMS)

EPA 402-R-93-078 October 1993 (Revised April 1994)

Contents

Exhibit 3

Document Cross Reference

E 2121 and the RMS are similar in document organization and the subjects embodied. During the development of E 2121, there was no conscious act taken to cause this to happen.

ASTM E 2121-01 (2001) ASTM Sections (Refer to Exhibit 1)	EPA RMS (1994) RMS TABLE OF CONTENTS (Refer to Exhibit 2)
(No Equivalent)	**1.0 Background**
1. Scope	**2.0 Purpose**
(No Equivalent)	**3.0 Participants**
2. Referenced Documents	See RMS "8.0 Reference Documents"
3. Terminology	See RMS "9.0 Description of Terms"
4. Summary of Practice	**4.0 Scope**
(No Equivalent)	**5.0 Assumption**
(No Equivalent)	**6.0 Implementation**
5. Significance and Use	**7.0 Limitations**
See ASTM "2. Referenced Documents"	**8.0 Reference Documents**
See ASTM "3. Terminology"	**9.0 Description of Terms**
6. Safety Hazards	See RMS "12.0 Worker Health and Safety"
7. Standard Practices for Mitigation	**10.0 General Practices**
7.1 General Practices:	**11.0 Building Investigation**
See ASTM "6. Safety Hazards"	**12.0 Worker Health and Safety**
7.2 Systems Design:	**13.0 Systems Design**
7.3 System Installation:	**14.0 Systems Installation**
7.4 Materials:	**15.0 Materials**
7.5 Monitors and Labeling:	**16.0 Monitors and Labeling**
7.6 Post-Mitigation Testing:	**17.0 Post-Mitigation Testing**
7.7 Documentation:	**18.0 Contracts and Documentation**
8. Keywords	(No Equivalent)

Exhibit 4
System Installation Cross Reference

ASTM E 2121-01 Sections		RMS TABLE OF CONTENTS	
7.3	System installation:	14.0	Systems Installation
7.3.1	General Requirements:	14.1	General Requirements
7.3.2	Radon System Piping Installation Requirements:	14.2	Radon Vent Pipe Installation Requirements
7.3.3	Radon Fan Installation Requirements:	14.3	Radon Vent Fan Installation Requirements
	See ASTM "7.3.5 Active Sub-Slab Depressurization (SSD) Requirements:"	14.4	Suction Pit Requirements for Sub-Slab Depressurization (SSD) Systems
7.3.4	General Sealing Requirements:	14.5	Sealing Requirements
7.3.5	Active Sub-Slab Depressurization (SSD) Requirements:		See RMS "14.4 Suction Pit Requirements for Sub-Slab Depressurization (SSD) Systems"
7.3.6	Sump Pit Requirements:		(No Equivalent Section) See RMS sub-section 14.5.1.
7.3.7	Drain Tile Depressurization (DTD) Requirements:		(No Equivalent Section) See RMS sub-section 14.2.9.
7.3.8	Submembrane Depressurization (SMD) Requirements:		(No Equivalent Section) See RMS sub-section 14.5.6.
7.3.9	Hollow Block-Wall Depressurization (BWD) Requirements:		(No Equivalent Section) See RMS sub-section 14.5.3.
7.3.10	Crawlspace Depressurization (CSD)		(No Equivalent Section) See RMS sub-section 14.5.8.
7.3.11	Combination Foundations:		(No Equivalent Section) See RMS sub-section 14.5.7.
7.3.12	Electrical Requirements:	14.6	Electrical Requirements
7.3.13	Drain Installation Requirements:	14.7	Drain Installation Requirements
7.3.14	HVAC Installation Requirements:	14.8	HVAC Installation Requirements
7.3.15	Heat Recovery Ventilation (HRV):		(No Equivalent Section) See RMS sub-sections 14.8.3 through 14.8.6.

Exhibit 5

Rationale for Discontinuing Backdrafting Test

Dr. Niren L. Nagda, Ph.D, of ENERGEN Consulting, Inc., an author of ASTM E 1998* and a contributor to the Gas Research Institutes Report GRI - 99/0186, dated August 1999, titled "Initial Surveys on Depressurization-Induced Backdrafting and Spillage" informed the E 2121 task group that short term backdrafting tests lead to unreliable conclusions and should no longer be done in the field or required in the standard.

Short term tests like those defined in ASTM E 1998 do not properly predict backdrafting in real world situations. The short term backdrafting tests predict backdrafting when there is none; but worse, the short term tests also predict no backdrafting when there may be some actual backdrafting.

Based on these research findings, the use of short term backdrafting tests can not be recommended or required because they may not lead to valid conclusions.

The chances of backdrafting are reduced when natural draft combustion appliances and venting systems have been installed and are operating according to codes and local regulations.

The long term test in ASTM E 1998 appears to be technically valid for predicting the potential for backdrafting in the long term, but it takes more than a week and may need to be performed during both summer and winter seasons.

Thus checking for compliance with venting system codes is a necessary first step before making any further evaluations, including long term backdrafting testing.

* ASTM E 1998 is the ASTM standard for backdrafting.

Exhibit 6

Terminology used for Radon System Piping in ASTM E 2121

"3.2.17 radon system piping, n — this active or passive soil depressurization piping is composed of three parts: suction point piping, manifold piping, and vent stack piping." © by ASTM

"3.2.24 suction point piping, n —one end of this piping penetrates the slab, the solid wall, the hollow wall, the membrane, the sump cover, or the drain tile. The other end extends outward to the first accessible pipe connection beyond the penetration of the soil-gas barrier." © by ASTM

"3.2.10 manifold piping, n — this piping collects the flow of soil-gas from two or more suction points and delivers that collected soil-gas to the vent stack piping. In the case of a single suction point system, there would be no manifold piping since suction point piping would connect directly to vent stack piping. The manifold piping starts where it connects to the suction points and ends where it connects to the vent stack piping." © by ASTM

"3.2.26 vent stack piping, n — this piping collects the soil-gas from the suction point or from the manifold piping of multi-suction point systems. There are no branches in vent stack piping; soil-gas is collected at one end of the vent stack piping and discharges from the building at the other end. In active soil depressurization systems, the radon fan is installed in the vent stack piping." © by ASTM