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Building Performance – Installing and Validating Building Envelope | 建筑性能——安装和验证建筑围护结构

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With UL since 1989, Alfredo (Al) Ramirez of UL LLC is the Regional Manager of Codes and Advisory Services, which primarily works with code authorities and architects globally (Asia, Europe, Middle East and Latin America). This group provides assistance, domestically and internationally, to clarify UL Certified product installation parameters and resolve product acceptance issues and potential conflicts between UL requirements and installation codes, among other things.

1989年加入美国安全检测实验室有限公司，拉米雷斯·艾尔弗雷多（艾尔）是建筑规范和顾问服务团队的区域经理，这个团队主要和世界范围内（亚洲、欧洲、中东和拉丁美洲）的规范部门和建筑师事务所打交道。团队为UL在验证UL认证产品安装参数，解决产品验收问题和UL要求与安装规范潜在冲突方面提供国内外的帮助。

Abstract | 摘要

Curtain walls are an essential component of the building envelope system that protect the building structure, occupants and contents from the adverse effects of weather and the outdoor environment. As architects create new and aesthetically pleasing curtain wall designs that incorporate unique windows and different types of building materials, testing becomes critical to ensure these new designs will provide adequate protection from water and air leakage.

Keywords: Building Code, Façade, Performance, Wind

幕墙是建筑围护体系的基本组成部分，用于防止建筑结构、居住者及内部物体遭受天气和户外环境的负面影响。建筑师不断追求新颖而令人愉悦的幕墙设计，这些设计结合各种材料制成的独特窗户及面板。对这些幕墙进行性能测试，以确保材料和设计的新组合能提供适当的防水防漏，这一点变得越来越重要。

关键词：建筑规范、幕墙、性能、风

Presently, there are prescriptive and performance requirements that have been developed and published by several North American standards and codes development organizations. They standards and codes writing organizations include:

- American Society for Testing and Materials (ASTM)
- American Architectural Manufacturers Association (AAMA)
- Florida Building Council
- International Code Council
- Steel Door institute
- Underwriters Laboratories

Building Performance requirements have evolved in the standards and codes published by the standards and codes writing organizations, which are referenced in model codes and a variety of construction specifications used for buildings constructed around the globe. Some of the relevant documents include:

- AAMA/WDMA/CSA 101/I.S.2/A440 – North American Fenestration Standard/Specification for Windows, Doors and Skylights
- AAMA 501 – Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure

目前，几个北美标准及规范制定机构制定并发布了一些规范及性能要求。这些标准和规范编写机构包括：

- 美国材料与试验协会（ASTM），
- 美国建筑制造商协会（AAMA），
- 佛罗里达建筑委员会
- 国际规范委员会
- 防盗门机构
- 美国保险商实验室

建筑性能要求已在标准和规范编写机构发布的标准和规范中形成，并被引用于标准及各种施工规范，用于在世界各地建造的建筑物。有关参考文件如下：

- AAMA / WDMA / CSA 101 / I.S.2/ A440——北美窗户、门及天窗开窗标准 / 规范
- AAMA 501——窗户、幕墙及门漏水的动压标准测试方法
- ASTM E330——外窗、门、天窗及幕墙结构性能的均布静压差标准测试方法
- ASTM E331——外窗、天窗、门及幕墙漏水的静压标准测试方法
- ASTM 283——测定外窗、幕墙及门在样本指定压差下漏气率的标准测试方法
- ASTM E783——现场测量已安装外窗及门漏气的标准测试方法

• ASTM E330 – Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference

• ASTM E331 – Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference

• ASTM 283 – Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

• ASTM E783 – Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors

• ASTM E1677 – Standard Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls

• ASTM E1886 – Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials

• ASTM 1105 – Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference

• ASTM E2387 – Standard Test Method for Determining Air Leakage of Air Barrier Assemblies

• TAS 201 – Impact Test Procedures

• TAS 202 – Criteria for Testing Impact & Nonimpact Resistant Building Envelope Components Using Uniform Static Air Pressure

• TAS 203 – Criteria for Testing Products to Cyclic Wind Pressure Loading

• SDI-BHMA A250.13 – Testing and Rating of Severe Windstorm Resistant Components for Swinging Door Assemblies

• International Building Code (IBC)

• International Energy Code (IECC)

These aforementioned codes and standards establish the minimum performance requirements for the building envelope and fenestration products. When curtain walls fail to meet these minimum requirements for preventing air and water leakage, the results can have a severe impact on the interior

Figure 1. Window with leakage (Source: UL)
图1. 窗户装置漏水（来源：UL）

building environment, including safety concerns, damage to building components and contents as well as increased energy costs for heating or air conditioning. The cost for repairing a leaking curtain wall that did not undergo initial mock-up testing or field testing and may not have been assembled or installed correctly is often financially significant and can be disruptive to the normal operation of the building and its occupants (Figure 1).

The complexity of curtain wall designs that utilize unique styles or window sizes and doors along with different façade components and insulating materials can create significant challenges in meeting all the applicable model code requirements intended to ensure an air- and water-tight building envelope. One cost-effective and time saving solution is to conduct both curtain wall mock-up testing and field testing of curtain walls during different phases of construction. This testing will assure the architect of record and building owner of code compliance with model code requirements for fenestration and reduce the negative impacts or unintended consequences of curtain wall water or air leakage.

To address the ever changing compliance landscape, technology advancements and importance of curtain wall testing, architects, designers, building owners and the construction community need to continually rely on curtain wall mock-up testing and field testing to determine the rate of air infiltration, water penetration, structural, impact and cyclical performance for windows, doors and curtain walls. Evaluating air and water resistance and the structural integrity of a building envelope with mock-up testing and on-site field testing provides the aforementioned parties with the critical information needed

• ASTM E1677——低层构架建筑墙用空气阻滞（AB）材料或系统的标准规范

• ASTM E1886——受发射物冲击以及暴露在循环压差下的外窗、幕墙、 门和冲击保护系统性能的标准测试方法

• ASTM 1105——现场测试外窗、天窗、门和幕墙漏水的均布或循环静压差标准测试方法

• ASTM E2387——测定气障组件漏气的标准测试方法

• TAS 201——抗冲击测试程序

• TAS 202——用均布静压力测试抗冲击及不抗冲击建筑围护结构的标准

• TAS 203——用循环风压测定产品的标准

• SDI-BHMA A250.13——转门抗严重风暴组件的测试和评级

• 国际建筑规范（IBC）

• 国际能源规范（IECC）

上述规范和标准确立了建筑围护结构和开窗产品的最低性能起点要求。如果幕墙不符合防止漏水漏气的最低要求，可能会对内部建筑环境造成严重的影响，包括安全问题、建筑构件及内部物体的损坏以及取暖或空调能源成本的上升。对于未进行初步实体模型测试或现场测试的漏水幕墙，由于可能存在的错误组装或安装，其维修成本通常较高，并会对建筑物及其居住者造成破坏性影响（图1）。

幕墙设计的复杂性（利用独特的风格或门窗尺寸及不同立面组件和保温材料）对符合所有适用标准和规范要求带来了挑战，以确保防漏水防漏气的建筑围护结构。在不同的施工阶段对幕墙进行实体模型测试

to assess performance and risk – from pre-construction all the way through to post-installation. This data helps assure manufacturers that their products will meet building design, building code, and product certification requirements (Figures 2, 3 & 4).

Compliance Testing for Fenestration Requirements in the IBC

Chapter 14 of the International Building Code provides initial guidance on fenestration requirements. Specifically, Section 1403.2 of the 2015 International Building Code requires exterior walls of a building to be

和现场测试是一种经济划算且节省时间的解决方案。该测试确保登记建筑师和规范业主遵循开窗的标准规范要求，并减少幕墙防水防漏的负面影响或非预期后果。

为处理不断变化的合规景观、技术进步及幕墙测试的重要性，建筑师、设计师、业主及施工单位必须不断进行幕墙实体模型测试和现场测试，以测定窗户、门及幕墙的漏气率、漏水、结构、冲击及循环性能。通过实体模型测试和现场测试评估建筑围护结构的防漏气漏水和结构完整性，这为上述各方提供了必要的关键信息，从而评估施工前到安装后的性能和风险。该数据有助于厂商的产品符合建筑设计、建筑规范及产品认证要求（图2–4）。

IBC开窗要求的符合性测试

国际建筑规范第14章对开窗要求提供了初步指引。2015年国际建筑规范第1403.2节明确要求建筑物外墙应装有防风防雨等有害气候的外墙围护结构。外墙维护结构是一种包括外墙涂料在内的外墙组件系统，这个系统会对建筑框架结构和外饰材料提供保护，使之免爱外部环境侵蚀和本身老化的影响。

外墙系统的设计和构造必须防止危害性天气的影响。外墙保温和饰面系统（EFIS）（如幕墙）使用组件组合形成外部围护结构，必须符合气候防护要求。IBC要求通过在外表面后提供防水屏障来防止外墙组件的内积水，用于排出进入组件及外部的积水。还必须防止外墙组件内出现冷凝露水。

如某些混凝土和砌体墙不需要防护灾害性气候时，可选择仅对外墙提供防水防漏性能测试。

漏水性能测试符合ASTM E 331

当测试样本已通过2小时的模拟耐风雨测试，且在过程中涉及接缝、渗透和与异质材料的交叉点时，国际建筑规范可以免去对外墙围护结构提供排水措施的要求。该测试必须根据ASTM E331（外窗、天窗、门及幕墙漏水静压力标准测试方法）进行。当通过均布静压向户外立面和暴露边同时供水时，可利用该测试来测定外窗、幕墙、天窗及门的防水性。

外墙围护结构的设计应能抵抗风雨。根据ASTM E 331规定，在测试中，雨水不得渗入外墙围护结构内的控制缝、开口四周或与异质材料在终端交叉点处的接缝。

Figure 2. Mock up testing – façade (Source: UL)
图2. 建筑围护结构实体模型测试（来源：UL）

Figure 3. Field testing – façade (Source: UL)
图3. 幕墙现场测试（来源：UL）

Figure 4. Façade testing – preparation (Source: UL)
图4. 幕墙测试准备（来源：UL）

provided with a weather-resistant exterior wall envelope. The exterior wall envelop is a system or assembly of exterior wall components, including exterior wall finish materials, that provides protection of the building structural members – including framing and sheathing materials – and conditioned interior space, from the detrimental effects of the exterior environment and proper draining.

The exterior wall system must be designed and constructed to prevent damage from rain, snow, wind and other weather events. Exterior Insulation and Finish Systems (EFIS) like curtain walls use a mixture of components to form the outer building envelope, and must also meet weather resistance requirements. The IBC requires prevention of water accumulation within the wall assembly by providing a water-resistive barrier behind the exterior veneer and a means for draining water that enters the assembly to the exterior. Protection against condensation within the exterior wall assembly must also be provided.

There are exceptions for when weather protection is not required, such as for certain concrete and masonry walls. One option for providing code mandated weather protection for exterior walls is through performance testing for water penetration and air leakage.

Water Penetration Performance Testing To ASTM E 331

The International Building Code does not require a means of drainage be provided for the exterior wall envelope when a representative test sample has been tested to resist a two hour simulated wind-driven rain, including joints, penetrations and intersections with dissimilar materials. The test must be conducted in accordance with ASTM E 331, the Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference. This test is used to determine the resistance of exterior windows, curtain walls, skylights, and doors to water penetration when water is applied to the outdoor face and exposed edges simultaneously with a uniform static air pressure.

The exterior wall envelope design shall be considered to resist wind-driven rain where the ASTM E 331 testing indicates that water did not penetrate control joints in the exterior wall envelope, joints at the perimeter of openings or intersections of terminations with dissimilar materials.

Air Leakage Testing in the International Building Code

To demonstrate compliance with the wind resistance requirements of the International Building Code, testing to evaluate the air leakage rates of exterior windows, curtain walls, and doors under specified differential pressure conditions across the specimen should be done in accordance with ASTM E 283, the Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specific Pressure Difference Across the Specimen. This test method is for tests with constant temperature and humidity across the specimen, and is intended to measure only such leakage associated with the assembly and not the installation. The test method can be adapted to evaluate the overall installation if needed. More detailed air leakage requirements are contained in the International Energy Conservation Code detailed further below.

On Site Testing During the Construction Period

Field air leakage tests on installed exterior windows and doors to validate correct installation practices should contemplate conducting testing in accordance with ASTM E 783, Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors, and field water leakage tests with ASTM E 1105, Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference. Field testing may be required by some jurisdictions as well as providing confirmation to designers and owners that these systems are safe, durable and energy efficient. These tests evaluate leakage at three different stages of curtain wall construction in accordance with standards produced by American Architectural Manufacturers Association (AAMA); standards AAMA 502, Voluntary Specification for Field Testing of Newly Installed Fenestration Products, or AAMA 503, Voluntary Specification for Field Testing of Newly Installed Storefronts, Curtain Walls and Sloped Glazing Systems (Figure 5).

IECC Requirements

The International Energy Conservation Code covers a broad spectrum of energy conservation issues that apply to the outer

国际建筑规范内的漏气测试

为证明防风要求符合国际建筑规范，应根据ASTM E 283（测定外窗、幕墙及门在指定样本压差条件下的漏气率的标准测试方法）进行测试，以评估外窗、幕墙及门在指定样本压差条件下的漏气率。该方法适用于具备样本恒定温度和湿度的测试，而且仅用于测量与组件相关（与安装无关）的此类泄漏。如有必要，也可采用该测试方法评估整个安装过程。下文详述的国际节能规范中包含了更多具体的漏气要求。

施工阶段的现场测试

对已安装外窗及门进行现场漏气测试，以验证安装的正确与否，应根据 ASTM E 783（现场测量已安装外墙和门漏气的标准测试方法）和ASTM E 1105（用均布或循环静压差测定已安装外窗、天窗、门及幕墙漏水的标准测试方法）对测试方法和具体步骤进行周密考虑。一些辖区可能需要现场测试并要求设计师和业主进行确认，从而使这些系统安全、耐用以及高效节能。根据美国建筑制造商协会（AAMA）、标准AAMA 502（新安装开窗产品的现场测试自愿规范）或AAMA 503（新安装店面、幕墙及倾斜玻璃装配系统的现场测试自愿规范）制定的标准，对幕墙施工中三个不同阶段的泄漏进行评估（图5）。

IECC要求

国际节能规范涵盖较为广泛，适用于外部围护结构及内部建筑系统，如照明及HVAC系统。国际节能规范用于商业建筑的时候通常包括开窗和蓄热要求，适用于建筑围护结构的所有部件。一般热要求在表C402.1和C402.2中详述。

屋顶的节能要求还包括太阳能反射率和热发射率，在第C402.2.1节说明。如果屋顶部分包括或被以下组件覆盖，这些要求可以规避：

1. 光电系统或组件
2. 太阳能供气或供水加热系统或组件

Figure 5. Window testing pressure testing – field location (Source: UL)
图5. 窗口压力测试–现场定位（来源：UL）

building envelope to internal building systems like lighting and HVAC systems to name a few. The International Energy Conservation Code includes fenestration and thermal conservation requirements for commercial buildings only and applies to all parts of the building envelope. Overall general thermal requirements are detailed in Tables C402.1 and C402.2.

Roofing-specific requirements including Solar Reflectance and Thermal Emittance are defined in Section C402.2.1. Roofs are exempt from these requirements if the portions of roofs include or are covered by:

1. Photovoltaic systems or components
2. Solar air or water heating systems or components.
3. Roof gardens or landscaped roofs.
4. Above-roof decks or walkways.
5. Skylights.
6. HVAC systems, components, and other opaque objects mounted above the roof.

Air leakage requirements are covered in Section C402.4 and apply to air barriers that are either located in the interior or exterior of the building envelope and air leakage requirements of a building's fenestration.

The International Energy Conservation Code requires air leakage of all building envelope assembly materials and components to not exceed an average 0.04 cfm/ft2 under a pressure differential of 0.3 inches of water gauge when tested to requirements contained in ASTM E 2357, the Standard Test Method for Determining Air Leakage of Air Barrier Assemblies; ASTM E 1677, the Standard Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls; or ASTM E 283, the Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen. Building envelope assemblies that are either constructed out of concrete masonry walls coated with one application either of block filler and two applications of paint or sealer coating; or Portland cement/sand parge, stucco or plaster minimum 1/2 inch thickness are excluded from testing.

The International Energy Conservation Code requires the air leakage of fenestration assemblies shall comply with the maximum leakage requirements detailed in Table C402.4.3 and tested by an accredited, independent testing laboratory and labeled by the manufacturer. Testing requirements vary by fenestration object and include references to AAMA/WDMA/CSA101/I.S.2/A440, the North American Fenestration Standard/Specification for Windows, Doors and Skylights; ASTM E 283, the Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen; and NFRC 400, the Procedure for Determining Fenestration Product Air Leakage. Fire doors evaluated to UL 1784, Standard for Air Leakage Tests of Door Assemblies and other Protective Openings, are exempted to additional testing to the aforementioned standards.

Summary

Architects, designers and contractors will continue to be challenged in designing/constructing a building whose design is innovative, efficient and performs as expected for tenants, but also suitable for its environment (Figure 6 & 7). The suitability of materials and assemblies are being defined by Model Installation Codes, in particular the

Figure 6. Field testing – water penetration (Source: UL)
图6. 渗水现场测试（来源：UL）

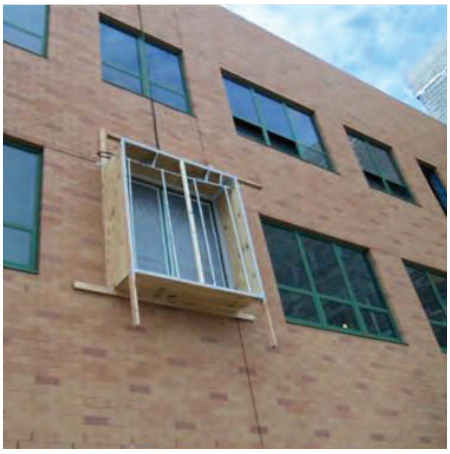

Figure 7. Window field testing (Source: UL)
图7. 建筑外窗的漏气测试（来源：UL）

3. 屋顶花园或景观屋顶。
4. 浮顶板或走道。
5. 天窗。
6. HVAC系统、组件及其他安装在屋顶上的不透明物体。

气密性要求在第C402.4节，适用于位于建筑结构内部或外部的气密件，及建筑物整体密封性能的要求。

国际节能规范要求建筑围护结构材料和组件的漏气在0.3英寸水位表压差下平均不超过0.04 cfm/ft2，测试要求包括在ASTM E 2357（测定气障组件漏气的标准测试方法）、ASTM E 1677（低层构架建筑墙用空气阻滞（AB）材料或系统的标准规范）及ASTM E 283（测定外窗、幕墙及门在指定压差下漏气率的标准测试方法）中。由混凝土砌体墙构造的建筑围护结构涂有一层封闭腻子和两层油漆或封闭涂层，或波特兰水泥/沙灰浆、泥灰或石膏（最薄1/2英寸），可排除测试。

国际节能规范要求开窗组件的漏气应符合表C402.4.3所详述的最低泄漏要求，并由认可的独立测试实验室进行测试，由厂商进行贴标。测试要求随开窗物体变化而变化，包括参考AAMA / WDMA / CSA101 / I.S.2 / A440（北美窗户、门及天窗开窗标准 / 规范）、ASTM E 283（测定外窗、幕墙及门在指定样本压差下漏气率的标准测试方法）及NFRC 400（开窗产品漏气的测定程序）。根据UL 1784（门组件及其他保护性开口的空气泄漏试验）评估的防火门不必进行符合上述标准的附加测试。

总结

建筑师、设计师和承包商不断挑战高效的创新性建筑设计 / 施工，并按照居住者的预期要求施工，还应适合其环境（图6、7）。材料及组件的适用性应遵守安装规范要求尤其是国际建筑规范和国际节能规范。这些规范通常用于大多数美国地区，同时，也适用于世界各地建筑。

风、雨及地震活动是标准规范中最常见的环境条件，但其随当今在建建筑的位置变化而变化，且能对建筑围护结构产生较大影响。所有这些条件都要求建筑师、设计师、安装者、承包商等采取措施，并注意标准 / 规范中的第三方要求及正确说明其适用性。

如存在验证漏气漏水要求的相关规范，在所有施工阶段应彻底落实执行，必须对业主及居住者负责任。然而，由于不断变化的材料、设计及建筑功能，有很多要求取

International Building Code and International Energy Conservation Code. These codes are regularly used in most jurisdictions in the United States and are now also being used in various architectural projects constructed or being constructed around the globe.

Wind, rain, and seismic activity are the most common environmental conditions contemplated in Model Codes, but vary in the locations where today's buildings are being constructed and can greatly impact building envelopes. All of these conditions require architects, designer, installers, and contractors, etc., to take action and look to third party requirements contained in standards/codes for guidance to correctly specify their applicability.

Prescriptive and performance paths to validate air infiltration and water penetration requirements exist and should be thoroughly vetted during all construction phases to provide continued assurance to the building owners and occupants. However, with ever changing materials, designs, and building functions, it is becoming more of a requirement to rely on performance options of testing design solutions in a laboratory setting and where necessary, additionally require field testing to validate actual installation practices.

Article Sidebar:

Water Leakage Often Results in Mold and Indoor Air Quality Issues

Unrecognized and uncorrected water infiltration through the curtain wall can quickly create an unhealthy indoor air quality due to harmful mold growing in hidden spaces. According to the EPA, molds can be found almost anywhere; they can grow on virtually any organic substance, as long as moisture and oxygen are present. There are molds that can grow on wood, paper, carpet, foods, and insulation. When excessive moisture accumulates in buildings or on building materials, mold growth will often occur, particularly if the moisture problem remains undiscovered or unaddressed. It is impossible to eliminate all mold and mold spores in the indoor environment. However, mold growth can be controlled indoors by controlling moisture indoors (Figure 8).

When moisture problems occur and mold growth results, building occupants may begin to report odors and a variety of health problems, such as headaches, breathing difficulties, skin irritation, allergic reactions, and aggravation of asthma symptoms; all of these symptoms could potentially be associated with mold exposure. All molds have the potential to cause health effects. Molds produce allergens, irritants, and in some cases, toxins that may cause reactions in humans. The types and severity of symptoms depend, in part, on the types of mold present, the extent of an individual's exposure, the ages of the individuals, and their existing sensitivities or allergies.

For more information on the health effects of mold, visit: http://www.epa.gov/mold/

Figure 8. Sidebar article - Façade with mold (Source: UL)
图8. 边栏–带霉菌的建筑物立面 （来源：UL）

决于实验室设置中测试设计方案的性能选择，必要时，需进行附加现场测试以保证实际安装质量的合格。

物品边栏：

漏水通常导致产生霉菌及影响室内空气质量问题

由于隐蔽空间内的有害霉菌生长，未被认可及未修正的幕墙透水会迅速产生不健康的室内空气。EPA指出，几乎任何地方都可以发现霉菌，只要存在水分和氧气，它们几乎可以在任何有机物上生长。木头、纸张、地毯、食品及保温材料等都会长出霉菌。当过多水分在建筑物内或建筑材料上积聚时，通常会出现霉菌，尤其是在水分问题未被发现或未被处理时。所有室内霉菌及霉菌孢子都不可能去除。只能通过控制室内水分来控制霉菌生长（图8）。

当出现水分问题并产生霉菌时，建筑物居住者可能开始抱怨气味及各种健康问题，如头痛、呼吸困难、皮肤刺激、过敏反应及哮喘症状加重；所有这些症状都与霉菌的存在有潜在关系。所有霉菌都有可能引起健康问题。霉菌会产生过敏原，有时候还会产生引起人类反应的毒素。症状类型和严重度主要取决于霉菌的类型、个人暴露在霉菌环境中的时间、年龄及其对霉菌的敏感性。

欲了解霉菌对健康影响的更多信息，请访问http://www.epa.gov/mold/。

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