ASHRAE

STANDARD

ANSI/ASHRAE Standard 160-2016
(Supersedes ANSI/ASHRAE Standard 160-2009)
Includes ANSI/ASHRAE addenda listed in Annex D

Criteria for Moisture-Control Design Analysis in Buildings

See Annex D for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

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ASHRAE obtains consensus through participation of its national and international members, associated societies, and public review.

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b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard, or
d. permission to reprint portions of the Standard.

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ANSI/ASHRAE Standard 160-2016,
Criteria for Moisture-Control Design Analysis in Buildings

NOTE

Approved addenda, errata, or interpretations for this standard can be downloaded free of charge from the ASHRAE website at www.ashrae.org/technology.

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

Although the majority of new buildings are safe, comfortable, and designed to provide effective protection against moisture-related problems, there are a certain number of buildings built each year that do experience moisture or mold problems. Whether this number is now increasing and whether the increase is due to the greater emphasis on energy-efficiency measures today is a widely debated topic. This purpose of this standard is not to answer either of these questions but rather to provide guidance on how to best design buildings with adequate moisture control features. Given its position as a leader in the proper design of heating, ventilating, and air-conditioning equipment, ASHRAE is uniquely qualified to provide such guidance.

During the last two decades, a number of computer simulation tools have been developed to predict thermal and moisture conditions in buildings and the building envelope. In addition to their use as forensic tools in the investigation of building failures, these computer models are increasingly used to make recommendations for building design in various climates. However, results obtained with these models are extremely sensitive to the assumed moisture boundary conditions. For instance, during winter in cold climates, the moisture conditions in walls depend greatly on the indoor humidity conditions. Thus, a consistent approach to moisture design demands a consistent framework for design assumptions, or assumed "loads." The question whether design features such as vapor retarders or ventilation systems are necessary cannot be answered objectively unless there is a consensus definition of the interior and exterior moisture boundary conditions that the building is expected to be able to sustain without negative consequences to itself or its inhabitants. This standard formulates design assumptions for moisture design analysis and criteria for acceptable performance.

Ideally, a design analysis involves the determination of the probability of failure and treats all design parameters and loads as stochastic variables. However, sufficient data are often not available to make a full statistical treatment practical. Instead, where only limited data exist, a moisture design protocol must be based on a combination of statistical data and professional judgment. Another judgment involves the choice of an acceptable probability of the occurrence of damage. Although it is common to impose very stringent criteria for structural design because of safety concerns, moisture damage usually occurs over a long period of time and usually has less catastrophic, although sometimes costly, consequences. An international consensus has emerged that the analysis should be predicated on loads that will not be exceeded 90% of the time. This standard adopts this approach.

In a moisture analysis for building envelope design, the choice of indoor environmental conditions is extremely important, especially for buildings in cold climates. This standard opts for a design indoor climate definition that is based on engineering principles, is independent of construction, and reflects the influence of ventilation and air-conditioning equipment and controls that may or may not be part of the building design. In buildings where indoor humidity and temperature are explicitly controlled, the building envelope performance should be evaluated with the intended indoor design conditions. In residential buildings, indoor humidity is rarely explicitly controlled, so default design assumptions are needed for these buildings. In general, the standard encourages designers to use their own design parameter values if they are known and part of the design. If they are unknown or not included in the design, the standard provides default values for those loads and parameters.

The standard does not address design details that deal with rainwater intrusion, plumbing leaks, ground water, and water damage caused by natural disasters such as floods and hurricanes. While proper design for these issues is extremely important, and damage from such events involves a large percentage of moisture damage in buildings, they can be more effectively addressed by codes, training of the trades, and specific design guidelines (see Annex B, "Commentary on Standard 160"). This standard assumes that appropriate measures were taken to limit bulk water entry into the building and building envelope. It does not intend to replace the judgment of the design professional. Rather, it provides a framework for the design professional to identify and consider factors that are important to the durability and serviceability of the building. In addition, many items in this standard are based on incomplete information and are, therefore, partially based on the best professional judgment of the standard committee at the time of writing. The development of this standard has pointed to many unanswered questions, questions that hopefully will be addressed and answered by research in the near future.

Since the document was published in 2009, ASHRAE Standard 160 has incorporated several addenda focused on

a. *simplifying the conditions necessary to minimize mold growth by eliminating two criteria,*
b. *limiting indoor relative humidity to 70% or less in the design analysis and revising the residential design moisture generation rates,*
c. *simplifying the calculation procedure for wind-driven rain without significantly impacting the accuracy of results,*
d. *updating references, and*
e. *replacing the simplified mold growth criterion with a mold index that predicts risk, which is more consistent with assembly performance observed in the field.*

The revised standard reflects the current state of knowledge about mold growth while providing less stringent criterion.

1. PURPOSE

The purpose of this standard is to specify performance-based design criteria for predicting, mitigating, or reducing moisture damage to the building envelope, materials, components, systems, and furnishings, depending on climate, construction type, and HVAC system operation. These criteria include the following:

a. Criteria for selecting analytic procedures
b. Criteria for inputs
c. Criteria for evaluation and use of outputs

2. SCOPE

2.1 This standard applies to the design of new buildings and to the retrofit and renovation of existing buildings.

2.2 This standard applies to all types of buildings, building components, and materials.

2.3 This standard applies to all interior and exterior zones and building envelope cavities[B-1].

2.4 This standard does not directly address thermal comfort or acceptable indoor air quality[B-1].

2.5 This standard does not address the design of building components or envelopes to resist liquid water leakage from sources such as rainwater, ground water, flooding, or ice dams.[B-1]

Informative Note: All superscript notes such as B-1, B-2, and so forth refer to informative commentary on the standard that is contained in Informative Annex B.

3. DEFINITIONS, ABBREVIATIONS, AND SYMBOLS

3.1 Definitions

24-hour running average: a continuously updated average of values over the most recent 24 hours.

30-day running average: a continuously updated average of values over the most recent 30 days.

airtight construction: construction in which the building envelope is designed with a continuous air barrier[B-2].

as-built: the condition of a building assembly in a completed structure that accounts for an expected level of deviation from the ideal construction of that assembly in order to allow for construction tolerances, discontinuities, and minor defects.

continuous air barrier: the combination of interconnected materials, assemblies, and flexible sealed joints and components of the building envelope that provide airtightness.

EMC80: the moisture content of a material expressed as a ratio of the mass of water and the oven-dry mass when the material is in equilibrium with air at 80% rh at 20°C (68°F).

EMC90: the moisture content of a material expressed as a ratio of the mass of water and the oven-dry mass when the material is in equilibrium with air at 90% rh at 20°C (68°F).

low-slope roof: a roof with a slope of less than 1 in 6, or 9.5°.

moisture-design reference years: the 10th-percentile warmest and 10th-percentile coldest years from a 30-year weather analysis[B-3].

residential: pertaining to single-family or multifamily dwellings, including high-rise residential buildings and manufactured homes.

rain runoff: the rainwater contribution that is drained from building elements above the element under consideration.

steep-slope roof: a roof with a slope equal to or greater than 1 in 6, or 9.5°.

surface relative humidity: the equilibrium relative humidity of air in contact with a surface of a given moisture content.

water-resistive barrier: a continuous material layer, other than the exterior surface, within a wall assembly, the purpose of which is to resist the inward migration of liquid water.

3.2 Abbreviations and Symbols

c	=	1.36×10^5 m²/s² (10.7 in. Hg. ft³/lb)
F_D	=	rain deposition factor
F_E	=	rain exposure factor
F_L	=	empirical constant, 0.2 kg·s/(m³·mm) [SI], 0.46 lb·h/(ft²·mi·in.) [I-P]
g	=	gravitational acceleration constant, 9.81 m/s² (32.2 ft/s²)
H	=	height of the building, m (ft)
M	=	mold index value
$\dot{m}$	=	design moisture generation rate, kg/s (lb/h)
p_i	=	indoor vapor pressure, Pa (in. Hg)
$p_{o,24h}$	=	24-hour running average outdoor vapor pressure, Pa (in. Hg)
ΔP_s	=	design stack pressure, Pa (in. of water)
Q	=	ventilation rate, m³/s (cfm)
RH/rh	=	relative humidity, %
RH_{crit}	=	critical surface relative humidity, %
RH_s	=	surface relative humidity, %
r_h	=	rainfall intensity on a horizontal surface, mm/h (in./h)
r_{bv}	=	rain deposition on vertical wall, kg/(m²·h) [lb/(ft²·h)]
T_i	=	indoor temperature, °C or K (°F or °R)
T_o	=	outdoor temperature, °C or K (°F or °R)
$T_{o,24h}$	=	24-hour running average outdoor temperature, °C (°F)
$T_{o,daily}$	=	daily average outdoor temperature, °C (°F)
T_s	=	surface temperature, °C (°F)
U	=	hourly average wind speed at 10 m (33 ft) above ground level, m/s (mph)
V	=	building volume, m³ (ft³)
w_i	=	indoor design humidity ratio, kg/kg (lb/lb)
w_o	=	mean coincident design outdoor humidity ratio for cooling, 1% annual basis, kg/kg (lb/lb)
ρ	=	density of outdoor air, kg/m³ (lb/ft³)
θ	=	angle between wind direction and normal to the wall (see Figure 4.6.1)