High Performance IAQ Specification for Net Zero Energy Homes

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SUMMARY

The National Institute of Standards and Technology (NIST) constructed a Net Zero Energy Residential Test Facility (NZERTF) to support the development and adoption of cost-effective Net Zero Energy (NZE) designs and technologies. One key design objective was to provide for occupant health and comfort through adequate ventilation and reduced indoor contaminant sources. To improve source control, guidelines were implemented to utilize products with relatively low volatile organic compound (VOC) emissions, focusing on toxicity, sensory irritation and odor. Emphasis was placed on reducing formaldehyde emissions as well as VOCs from wet-applied materials and acetic acid. These guidelines were based largely on published research and product information, but were not part of the NZERTF architectural specifications. From the lessons learned in their application to the NZERTF, the guidelines were updated and formalized in the form of architectural specifications for use by architects and contractors interested in addressing high performance IAQ in netzero and other residential buildings.

INTRODUCTION

In 2009, the NIST Energy and Environment Division received funding to design, construct and operate a net zero energy residence in Gaithersburg, MD. The 250 m^2 two-story single-family unoccupied NZERTF residence was completed in 2012 (Pettit et al., 2014). It functions as a laboratory to support the development and adoption of cost-effective NZE designs, technologies, construction methods, and building codes. The primary design goal was to meet the comfort and functional needs of the presumed occupants. Other important goals include siting to maximize renewable energy potential, establishing an airtight and highly insulated building enclosure designed for water and moisture control, providing controlled ventilation, and installing highly efficient mechanical equipment, lighting and appliances. The NZERTF achieved its goal of generating more energy than it consumed during its first year of simulated occupancy, despite a severe winter (NIST, 2014).

Indoor air quality (IAQ) directly impacts the comfort, health and well-being of building occupants, making the achievement of acceptable IAQ in newly constructed and renovated buildings an important design objective. IAQ in homes is particularly important because Americans, on average, spend about 90 % of their time indoors with the majority of this time at home (EPA, 2011). Indoor concentrations of many air pollutants are often elevated in homes relative to outdoors because many materials and products used indoors contain and release a variety of air pollutants (Hodgson et al., 2002; Offermann and Hodgson, 2013). With respect to indoor air contaminants for which inhalation is the primary route of exposure, the critical design and construction parameters are the provision of adequate ventilation and the reduction of indoor contaminant sources.

Both of these pollutant control techniques were incorporated into the design of the NZERTF. Ventilation system design and specifications are described in Pettit et al. (2014). To control indoor contaminant sources, guidelines were developed for the selection of relatively low VOC emitting products used inside of the airflow control layer (or air barrier membrane), thereby reducing potential toxicity, sensory irritation, and odor annoyance. Particular emphasis was placed on reducing formaldehyde emission sources including composite woods. Acetic acid, an odorant and suspected chemical irritant found in numerous interior products, and VOCs emitted from wet-applied materials were also targeted.

These source control guidelines were largely prescriptive, based on published research and product information available at the time. The design team implemented the guidelines to the best of their ability, but found that it was generally difficult for product manufacturers and suppliers to verify the emission requirements except for the relatively simple product credits described in the LEED® for Homes building standard (Pettit et al., 2014). Despite these challenges, the IAQ objectives for the NZERTF largely were accomplished. The efforts to limit airborne concentrations of formaldehyde and other VOCs through ventilation and source control were investigated through a year-long IAQ monitoring study conducted to simulate occupancy (Poppendieck et al., 2014). This study concluded that the measures taken, such as reducing use of medium density fiberboard and particleboard in the cabinetry and other finished products were effective in reducing indoor formaldehyde concentrations. The results additionally suggested that specifications for low-emitting interior products along with ventilation rates consistent with ASHRAE Standard 62.2 (ASHRAE, 2013) could result in residences with lower indoor VOC emission rates and VOC concentrations than typical new homes that did not employ such specifications.

IAQ SPECIFICATIONS

Based on the lessons learned from the NZERTF effort, the guidelines for low-emitting interior sources were updated and formalized into a detailed architectural specification intended specifically for residential new construction and major renovations. This specification differs substantially from the original guidelines and emphasizes a more performance-based approach. This change was made due to the availability of considerably more VOC emissions product data generated by manufacturers interested in demonstrating compliance with LEED® low-emitting materials credits and the requirements of other high-performance building codes and standards. This specification is now available for download in Word format at the NZERTF web page on the NIST website (www.nist.gov).

Specification Section 01 81 13.01, Sustainability Requirements – Indoor Air Quality, aims to provide guidance for building professionals on IAQ topics for the design and construction of a “healthy” NZE home. It is intended for use by architects, contractors, and design-build contractors and provides guidance for the review, selection and specification of systems and products for residential projects, and is structured to assist in developing integrated specification documents governed by this Division 01 section.

The practices contained in the specifications are focused on interior finishes and other known indoor pollutant sources. Some of the main practices are summarized as follows:

1. Paints and Coatings: Shall not contain formaldehyde; shall be formulated with water-based technologies; VOC content (g/L) shall meet South Coast Air Quality Management District (SCAQMD) rule 1113 and/or California Air Resources Board (CARB) Suggested Control Measure (SCM).
2. Adhesives and Sealants: Shall not contain formaldehyde; VOC content (g/L) shall meet SCAQMD rule 1168; only limited quantities of silicone rubber caulks or sealants containing acetic acid shall be used.
3. Thermal and Acoustic Insulation: Shall not contain formaldehyde-based binder as an ingredient; shall be fire retardant free unless required by local building code.
4. Carpet and Carpet Cushion: Shall comply with Carpet & Rug Institute “Green Label Plus” program testing requirements for carpet and “Green Label” program testing

requirements for carpet cushion and shall comply with VOC emission requirements of CA Dept. of Public Health Standard Method V1.1.

5. Resilient and Tile Flooring: Shall comply with Resilient Floor Covering Institute (RFCI) "FloorScore®" program testing requirements in accordance with VOC emission requirements of CA Dept. of Public Health Standard Method V1.1.
6. Wood, Composite Wood, Agrifiber Products and Components: Shall comply with VOC emission requirements of CARB Airborne Toxic Control Measure (ATCM); interior moldings and trim shall be solid wood; shelving and panels shall be hardwood plywood with no-added formaldehyde veneer core.
7. Gypsum Board Walls and Ceilings: Gypsum wallboard shall be applied with conventional mechanical fasteners; solvent-containing adhesives shall not be used; panels shall comply with VOC emission requirements of CA Dept. of Public Health Standard Method V1.1.
8. Moisture and Mold Control: Drywall, other porous materials and components, and items with high organic content shall not be loaded into or stored in partially enclosed buildings; visible signs of mold and mildew that appear during construction shall be reported to Owner and Architect; damaged products shall not be used.
9. Attached Garage Pollutant Protection: Garage shall be enclosed with air barrier to effectively separate the habitable area of the home from the garage; garage shall use an exhaust fan with automatic timer controls linked to an occupant sensor, light switch, garage door opening mechanism, and a carbon monoxide sensor.

It is recognized that each residential project will have different objectives and requirements based on Owner's programmatic requirements, site conditions, climatic conditions, project size, and complexity. Accordingly, the specification is intended to be modified by the user. Editor's notes are provided throughout the Specification to guide the user in selecting appropriate requirements and in editing the document consistent with project requirements. An IAQ Compliance Table is provided to assist the specification user in tracking the IAQ compliance requirements for systems and products and for recording submittal documentation such as VOC emission test reports, product technical data sheets, product certifications and manufacturer's self-declared claims, as applicable.

Control measures for pollutants that that may expose occupants by pathways other than, or in addition to, inhalation are not as well established as control measures for VOCs. The specification contains optional requirements that may be used to expand the scope of pollutants by limiting products based on information about chemical ingredients.

The specification also addresses building commissioning, a process of verifying that the building is built and operates as designed and as intended. It recommends that users develop a process that is appropriate for the type, size, and complexity of their project in accordance with industry guidelines, building code requirements, and LEED certification requirements.

CONCLUSIONS

The IAQ specification is intended to support architects and contractors who pursue a higher level of IAQ performance in net zero and other residential buildings. The formal, but flexible, architectural specification language is intended to facilitate use by building professionals.

DISCLAIMER

Certain commercial programs and documents are identified in this paper in order to fully describe the concepts therein. Such identification is not intended to imply recommendation or endorsement by NIST, nor is it intended to imply that the programs and documents identified are necessarily the best available for the purpose.

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