

LEED - a new challenge for low VOC emitting materials.

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More and more sustainable buildings are designed and realised since a number of years. In this paper, US based LEED rating system is characterised with respect to their specifications of VOC emissions into indoor air. This is compared with European approaches.

LEED rating system

LEED[®], the US originated rating system for sustainable buildings, is requested by more and more building planners in the USA and in Europe and at the Gulf. Copies and modified versions of that rating system can be found in the Gulf region, in Italy, in Australia, and in some Asian regions. One example: In Italy there was founded Green Building Council Italia, using the US specifications. Other rating schemes can be found in Europe, see at end of this paper.

The U.S. Green Building Council (USGBC) is a non profit organization that developed and administers the LEED (Leadership in Energy and Environmental Design) Green Building Rating System.

Motivation for having LEED certification of a building is to achieve higher value of a building in company balance, or better sales or better rental price with sustainability as additional argument, or to promote public perception of the company operating a LEED certified building, or to promote environment and health. Procedure is to collect points by fulfilling "credits" for proper consideration of environmental aspects (e.g. saving of energy and of resources, recyclability, indoor air quality and more).

Use of low emitting materials is helping to achieve such points with respect to indoor air quality in the planned building. Motivation of product manufacturers to show that their product can support collecting LEED points ("**LEED compliance**") is that they can sell their products to those who want to achieve LEED certification of their building. But USGBC does not foresee any type of "LEED compliance" attestation of a product.

The **basic procedure** is:

- Manufacturer supplies documentation on LEED relevant product properties to its client.
- Building planner presents all documentation (including material documentation) to USGBC or to an approved certification body.
- There final acceptance is given and respective point is awarded within process of certification of the building project.

It is important to understand that **no product can be LEED approved**, but the manufacturer can produce documentation showing that **the product can help achieving LEED points**. If a product carries the logo of USGBC then this indicates nothing more than that the manufacturer is member of U.S. Green Building Council.

Most recent LEED specifications are for:

- Commercial Interior
- New Construction
- Schools
- Core and Shell
- Existing Buildings

Other specifications are about to follow.

LEED specifications for different materials are described below in detail, followed by specifications as issued by European sustainable buildings programmes. The following is restricted to earning points with respect to impact of products on indoor air quality. Other points may be achieved for recyclable and for recycled content.

LEED for adhesives, sealants, paints and coatings

Indoor Environmental Quality specifications by LEED, IEQ credit 4.1 and 4.2

There are VOC requirements for adhesives and sealants in the LEED 2009 specifications for

- Commercial Interior
- New Construction
- Core and Shell
- Existing Buildings (in credit MR3)

These go for VOC content determination, where all volatiles are determined by weight loss after drying at 110°C during 1h. Besides VOC, also water evaporates then. Therefore a water determination is added and all water is subtracted. Furthermore, all VOCs that are not relevant for ozone generation in ground-level atmosphere ("exempt compounds") are subtracted. Limit values are different per product group and application.

References methods include SCAQMD rule 1168 (adhesives and sealants) and rule 1113 (paints and coatings), SCAQMD methods 304 and 303, ASTM D2369 and D3960, EPA method 24. ISO 11890-1 (2007) is equivalent to ASTM D2369. SCAQMD stands for the Californian South Coast Air management District - the local authority with the most stringent VOC limits in the USA.

Origin of these criteria is protection against formation of ground-level ozone (as contribution to smog). In former times, these values were selected also for evaluating emissions into indoor air because earlier there had not been reliable VOC emissions labels in the USA. This has changed, and with next revision it may happen that these VOC content related criteria are replaced by VOC emission related criteria, but this has not yet been decided.

There are different VOC requirements for adhesives and sealants in the LEED 2009 specification for

- Schools

These go for VOC emission chamber testing in accordance with California Section 01350 specification. A comparison of test data showed the equivalency of EMICODE EC1, Blue Angel and California Section 01350 requirements for flooring adhesives and is available from the authors.

LEED for Textile Flooring Systems

Indoor Environmental Quality specifications by LEED, IEQ credit 4.3

There are VOC emission requirements for textile floor coverings in the LEED 2009 specifications for

- Commercial Interior
- New Construction
- Schools
- Core and Shell
- Existing Buildings (in credit MR3)

There are three ways of showing compliance.

Option 1: All carpet and all carpet cushion must meet the testing and product requirements of the Carpet and Rug Institute Green Label Plus program. This is shown by CRI Green Label Plus certification.

Option 2: All carpet and all carpet cushion must meet the testing and product requirements of the Carpet and Rug Institute Green Label Plus program. This is shown by emission chamber testing in an independent laboratory without CRI certification, and without using the expensive testing laboratory used by CRI.

Option 3: All flooring products must meet the testing and product requirements of the California Department of Public Health Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda - also called California Section 01350 specification. This is shown by emission chamber testing in an independent laboratory without CRI certification, and without using the expensive testing laboratory used by CRI.

Additionally, all carpet adhesive must have less than 50 g/L VOC, determined as specified in LEED credit IEQ 4.1, adhesives and sealants (SCAQMD rule #1168).

LEED for non-Textile Flooring Systems

Indoor Environmental Quality specifications by LEED, IEQ credit 4.3

There are VOC emission requirements for hard surface flooring in the LEED 2009 specifications for

- Commercial Interior
- New Construction
- Schools
- Core and Shell
- Existing Buildings (in credit MR3)

There are two ways of showing compliance.

Option 1: All hard surface flooring must be certified as compliant with the FloorScore standard by an independent third party. Flooring products covered by FloorScore include vinyl, linoleum, laminate flooring, wood flooring, ceramic flooring, rubber flooring and wall base. Only one US

based and one European laboratory are approved testing laboratories for testing within that process.

Option 2: All flooring products must meet the testing and product requirements of the California Department of Public Health Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda - also called California Section 01350 specification. This is shown by emission chamber testing in an independent laboratory without FloorScore certification.

Additionally, concrete, wood, bamboo, and cork floor finishes such as sealer, stain and finish must meet the requirements of as specified in LEED credit IEQ 4.2, paints and coatings (SCAQMD rule #1113). And, all tile setting adhesives and grout must meet criteria as specified in LEED credit IEQ 4.1, adhesives and sealants (SCAQMD rule #1168).

LEED for Composite Wood and Agrifibre Products

Indoor Environmental Quality specifications by LEED, IEQ credit 4.4

There are requirements on formaldehyde emitted from composite wood and agrifibre products in the LEED 2009 specifications for

- Commercial Interior
- New Construction
- Schools
- Core and Shell
- Existing Buildings (in credit MR3)

Composite wood and agrifiber products are defined as: Particleboard, medium density fibreboard (MDF), plywood, wheatboard, strawboard, panel substrates and door cores. These products must contain no added urea-formaldehyde resins when used on the interior of the building. The same applies to laminate adhesives used to fabricate on-site and shop-applied composite wood and agrifibre assemblies. Testing is not required. Materials considered fixtures, furniture, and equipment (FF&E) are not included. The same applies to products covered by IEQ Credit 4.5 dealing with system furniture and seating.

There are VOC emission requirements for composite wood and agrifibre products in the LEED 2009 specifications for

- Schools

All products must meet the testing and product requirements of the California Department of Public Health Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda - also called California Section 01350 specification. This is shown by emission chamber testing in an independent laboratory.

LEED for System Furniture and Seating

There are **VOC emission requirements for system furniture and seating** in the LEED 2009 specifications for

- Commercial Interior
- New Construction
- Schools

Limit values to be respected in a model office room:

System furniture:

- TVOC - 0.5 mg/m³
- Formaldehyde - 50 ppb
- Total aldehydes - 100 ppb
- 4-Phenylcyclohexene - 0.0065 mg/m³

Seating:

- Half the values of system furniture

There are three ways of showing compliance.

Option 1: Testing and calculation of test results into a typical model office shows indoor air concentrations that are less than or equal to those listed above for furniture systems and seating, based on ANSI/BIFMA M7.1-2007 and ANSI/BIFMA X7.1-2007 testing protocol, and tested in an independent and accredited third party air quality testing laboratory.

This can be shown either by just testing in a qualified laboratory, or by certification by an independent third party. Two US based and one European laboratory are approved testing laboratories for testing within that process.

Option 2: Furniture and seating are Greenguard Indoor Air Quality Certified.

Option 3: Same as option 1, but testing follows a 1999 EPA Large Chamber Test Protocol, tested in an independent air quality testing laboratory. Option 3 is not used any more in reality.

The option with best costs / benefit ratio clearly is option 1.

LEED for Ceiling and Wall Systems

Indoor Environmental Quality specifications by LEED, IEQ credit 4.6

There are VOC emission requirements for ceiling and wall systems in the LEED 2009 specifications for

- Schools

All products must meet the testing and product requirements of the California Department of Public Health Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda - also called California Section 01350 specification. This is shown by emission chamber testing in an independent and accredited laboratory.

Other Sustainable Building Rating Systems and IAQ

BREEAM, UK

British BREEAM (Building Research Establishment's Environmental Assessment Method) is an approach for promoting and certifying sustainable buildings. Motivation for having BREEAM certification of a building is the same as for LEED.

Credits are awarded in ten categories according to performance. These credits are then added together to produce a single overall score on a scale of **Pass, Good, Very Good, Excellent and Outstanding**. Regarding indoor air quality, use of low emitting products inside the building will be helpful for achieving a point if the following specifications have been proved by testing:

- Wooden products and any floorings:
 - E1 formaldehyde class applies, and no regulated wood preservatives are used.
- Suspended ceiling tiles:
 - E1 formaldehyde class applies, and no asbestos is used.
- Flooring adhesives:
 - No carcinogens and no sensitizers as defined in EN 13999-1 are emitted. As no testing schedule is defined in BREEAM documents, it can be assumed that this will require testing in test chamber after 1 day as specified in EN 13999 parts 2, 3, and 4, including determination of carcinogenic volatile compounds, volatile aldehydes, and volatile diisocyanates.
- Wall coverings:
 - Low emissions of formaldehyde and of vinyl chloride monomer, complying with standards EN 233, EN 234, EN 259, EN 266.
 - Migration of heavy metals and other toxic substances comply with above mentioned standards.
- Adhesive for hanging flexible wall coverings
 - No harmful substances, and preservatives used should be of minimum toxicity.
- Decorative paints and varnishes
 - VOC content as specified for phase 2 of EU Decopaint Directive. Shall be fungal and algal resistant.

French Démarche HQE certification

French HQE is an approach for promoting and certifying sustainable buildings in accordance with the HQE (Haute Qualité Environnementale) approach. Motivation for having HQE certification of a building is the same as for LEED.

There are 15 goals ("cibles") for which the levels **High performance, Performance, or Base** can be achieved, associated with collecting points for fulfilment of HQE specifications. This relates to several environmental aspects (e.g. saving of energy and of resources, recyclability, indoor air quality and more). Three audits are foreseen during building process for supporting and then for evaluating the sustainable building characteristics.

Regarding indoor air quality, an indoor air quality measurement is suggested after completing the building. Use of low emitting products inside the building will help achieving additional points. Basis for that evaluation is an emissions test using ISO 16000-9, -10 and -11 standards, and performed in an accredited testing laboratory. Existing low emission schemes are accepted as proof, such as AFFSET, AgBB, EMICODE, GUT, M1, E1 formaldehyde emission class (as defined e.g. in EN 13986, or in EN 14041, or in EN 14342).

Points are granted a.o. for:

- Knowledge of VOC and formaldehyde emission level for 25%, 50% or 100% of interior surfaces (more points for more coverage).
- CMR substances are within the limits as set by the accepted low emission labels.
- TVOC emissions of all products on floor, wall and ceiling are below 1000 or below 250 $\mu\text{g}/\text{m}^3$ (more points for lower emissions).
- Formaldehyde of all products on floor, wall and ceiling are below 62.5 or below 40 or below 20 or below 10 $\mu\text{g}/\text{m}^3$ (more points for lower emissions).
- Class 1 and class 2 carcinogens emissions of all products on floor, wall and ceiling are below 5 or below 2.5 or below 1 $\mu\text{g}/\text{m}^3$ (more points for lower emissions).

German DGNB

German DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen) is an association for promoting and certifying sustainable buildings. Motivation for having DGNB certification of a building is the same as for LEED. Procedure is to collect points for proper consideration of environmental aspects (e.g. saving of energy and of resources, recyclability, indoor air quality and more).

Regarding indoor air quality, an indoor air quality measurement has to be performed max. 4 weeks after completing the building. Then a number of limit values for trace air contaminants shall be respected. Use of low emitting products inside the building will be helpful for achieving this goal, but in contrast to other certification schemes, selection of low emitting products is not directly connected to earning points for DGNB certification.

Summary and Recommendations

Sustainable Building projects are gaining importance in the market. Low VOC emitting products may help to achieve rating of a building as "sustainable". Specifications on VOC emissions from applied materials are different per each characterised sustainable Building specification.

Future modifications should allow showing compliance by making use of different low VOC emission rating schemes, as already realised for e.g. the French HQE approach. A VOC workshop within Healthy Buildings Conference 2009 clearly showed the similarity of the several low VOC emissions rating scheme (details available from the authors).

As LEED projects are gaining importance also outside the USA, it is recommended that US Green Building Council opens their specifications towards local (e.g. European) low VOC labelling systems such as EMICODE, GUT, Blue Angel and more.

More details, and reference to original sources of information, can be found at the website of the authors, www.product-testing.eurofins.com (then click on LEED compliance).

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