# Building product VOC emission testing and conformity assessment procedures in the U.S.

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## SUMMARY
Low VOC-impact product criteria are included in most U.S. "green" building rating systems, codes, and purchasing programs. Currently, there is no public or private organization to guide the development of VOC emission requirements or to establish a common set of principles and practices for designating compliant products. Consequently, there are substantial variations in the requirements and considerable misunderstanding and confusion among stakeholders about what constitutes compliance. This paper illustrates the principles and the procedures involved in testing of a product sample for VOC emissions through to the creation of a valid product claim. Three significant contributors to deficiencies in current U.S. practice are identified, including the lack of coordination among the many standards, codes, and specifications, the lack of clear guidance regarding the establishment of product claims, and the lack of uncertainty analysis for the entire process. Recommendations for best-practice solutions are provided.

## IMPLICATIONS
Requirements for using low VOC-impact building products in green building design and construction are expanding rapidly. This paper can help stakeholders including standards organizations, code officials, manufacturers, and consumers better understand the processes of VOC emission testing and the designation of compliant products. Current deficiencies may be corrected by establishing better guidelines for key process elements.

## KEYWORDS
Product claim, certification, self-declaration, green building code, low VOC-impact product

## INTRODUCTION
Most existing and developing U.S. "green" building rating systems, building codes, standards, and purchasing programs include criteria related to VOC emissions from interior building products and, in some cases, commercial furnishings. Some of the many VOC emission standards and other specifications that may impact a product are shown in Table 1. Two recent, reviews are available (Levin, 2010; Singer and Willem, 2010). Additionally, a number of standards organizations now are developing multi-attribute "sustainability" programs for building products and furnishings that often include VOC emission testing requirements or credit options. These activities result in a complex system of inter-related, constantly evolving, and often poorly-coordinated standards, codes, and specifications. Many stakeholders including standards organizations, manufacturers, laboratories, certification bodies, government agencies, architects, and consumers don't fully understand the principles and procedures involved in VOC emission testing and the designation of compliant products.

Table 1. Types of standards, codes, specifications, and regulations related to VOC emissions

| Category | Characteristics |
|---|---|
| Test Methods | All testing aspects from sample collection through reporting |
| | May reference other standards, e.g., VOC sampling/analysis |
| Acceptance Criteria | May be incorporated into test method in some cases |
| | May reference governmental agency lists of VOCs of concern |
| Other Building and Product Standards, Specifications, Codes & Regulations | Multi-attribute sustainability standards, e.g., ANSI/BIFMA e3 |
| | Public and private purchasing specifications |
| | Rating and certification systems, e.g., LEED, GreenGlobes, CHPS |
| | Codes and Standards, e.g., CALGreen, ASHRAE 189.1, IgCC |
| | Regulations, e.g., CARB formaldehyde ATCM; EPA Asbestos, Lead, Pesticides |

## METHODS

This analysis of de facto U.S. policy regarding the voluntary and increasingly mandatory testing of products for VOC emissions begins with an overview of the steps involved in testing of a product sample for VOC emissions through to the creation of a product claim. We use CDPH/EHLB Standard Method v1.1 (CDPH, 2010) as the example because it is the most cited U.S. VOC emission standard. It is developed and maintained by a California state agency and is not full consensus standard. Within this framework, we discuss three significant contributors to deficiencies in current U.S. practice: a lack of coordination among the many standards, codes, and specifications; a lack of comprehensive guidance regarding the establishment of product claims; and a lack of an uncertainty analysis for the entire process. We conclude with recommendations for best-practice solutions to address these issues.

## DISCUSSION

### VOC Emission testing and product conformity assessment procedures

Although still evolving, the CDPH Standard Method covers all of the procedural steps from selection of representative product samples through establishment of claims for compliant products. The steps involved, the functions of the participants, and the required documentation are outlined in Figure 1. Two or more organizations are involved. A manufacturer making a self-declared (i.e., 1$^{st}$ party) claim needs only contract with an independent (i.e., 3$^{rd}$ party) laboratory. If certification of the claim is desired, the manufacturer also contracts with a third-party certification organization. The same third-party can serve as both laboratory and certifier provided there are adequate firewalls separating testing and certification functions. An industry trade group (i.e., 2$^{nd}$ party) or the certifier may be responsible for the environmental label associated with a claim. The process is divided into three stages: 1) product sample selection, collection and handling; 2) testing ranging from test specimen preparation through compilation of chamber data; and 3) conformity evaluation resulting in a claim for a compliant product. A certifier is expected to be directly involved in establishing a sampling plan and in auditing of the manufacturing process to determine if there are sufficient controls to ensure production of a consistent product. If there is no certifier, the manufacturer fully assumes these responsibilities and is required to have documented production controls and a written plan for selecting representative or worst-case representative product samples for product families. The laboratory tests the sample and reports results that are specific to the sample. Finally, either an independent (i.e., 3$^{rd}$ party) laboratory or a third-party certification organization conducts a conformity evaluation. The laboratory can issue a laboratory certificate of compliance for the test sample, which is intended to be used together with manufacturer self-declared claim. The certifier can issue a certificate of product compliance.

The entire process must be documented. The objective of this documentation is to relate the sample and the test results to a product in the marketplace. The paper trail for a certified claim consists of the product sampling plan, a chain-of-custody form that follows the sample, the laboratory emission test report for the sample, an internal certification report, and the certificate of product compliance, which is available for distribution to interested parties. For a self-declared claim, the manufacturer creates a certificate of conformity, to which the laboratory certificate is appended, stating that the test results are applicable to a product or group of products. If these procedures are followed, both the certified claim and the self-declaration should be sufficient proof of product compliance.

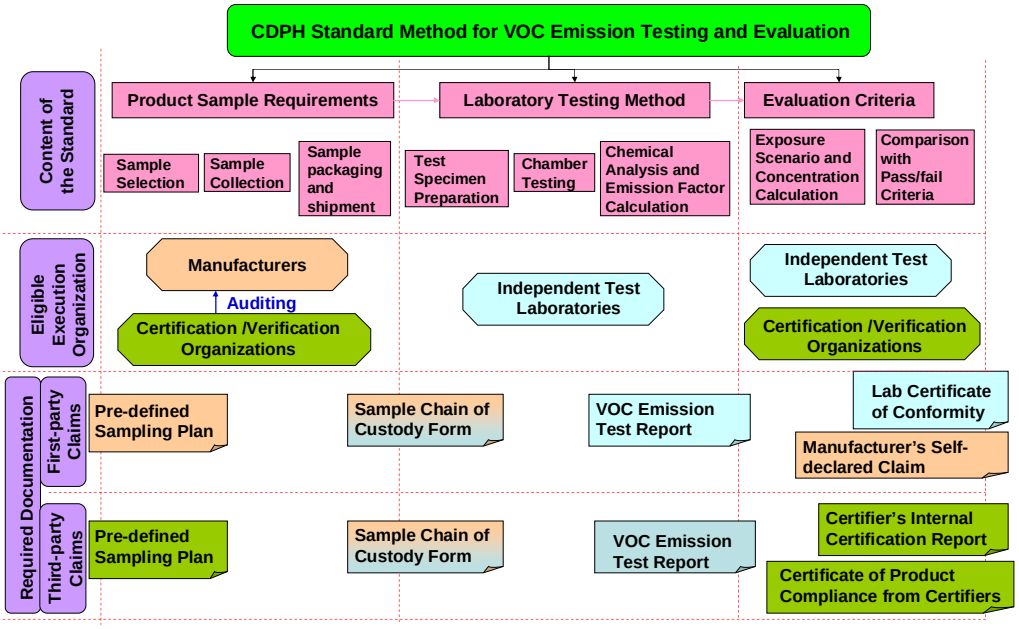


Figure 1. Schematic diagram of CDPH Standard Method procedures

**Deficiencies in current U.S. practice**

An obvious and significant contributor to deficiencies in the VOC emission standards and testing landscape in the U.S. is the general lack of coordination. Product claims related to VOC emissions are made in the context of a complex system of inter-related and sometimes contradictory, continually-evolving standards, codes, and specifications. Additionally, standards often reference other evolving standards or sources of information such as health guidelines. In other cases, standards may alter, add, or delete portions of other standards. Changes to standards occur on different time schedules dictated by the needs and requirements of the standards organizations. These changes are not synchronized and, in some cases, standard organizations may not even be aware of related activities in other organizations or may not have the appropriate experts as stakeholders. Due to the lack of coordination, inconsistencies go unresolved and significant lapses occur before the latest versions of references are incorporated into a standard. This uncoordinated situation makes it difficult for manufacturers and other parties to stay up to date and comply with requirements.

Another contributing factor is a general lack of specific guidance regarding the establishment of a valid VOC emission claim for a product. Test results by their nature are specific to the test item (ISO/IEC 17025, 2005). These results must be related to the marketed product. This step requires knowledge and control of manufacturing processes and selection of appropriate test samples. The CDPH Standard Method devotes a section to both self-declared and certified

product claims. It lacks detailed instructions but does establish requirements for manufactures and certification bodies related to manufacturing controls and selection of test samples. The Federal Trade Commission's 2010 draft "Guides for the Use of Environmental Marketing Claims," is intended to prevent marketers from making unfair or deceptive environmental claims. However, it is much too general to ensure strong VOC emission product claims.

ISO/IEC Guide 65 (1996) establishes the quality system for third-party certification bodies but is also overly general. It simply requires that certification bodies operate an effective quality system and make available documentation describing the certification process, their rules and procedures for granting certification, the fees that are charged, the duties and rights of applicants, and the handling of complaints, appeals and disputes. Certification organizations have interpreted these broad guidelines in various ways, and accreditation bodies may have different procedures and requirements for granting accreditation to certifiers. The resulting inconsistency among competing certification programs indicates a need for more specific guidance.

While some attention has been directed at assessing the uncertainty associated with laboratory measurements of VOC emissions, treatment of uncertainty is another inadequacy in U.S. VOC emission standards. There is a basis for concern as many inter-laboratory studies have shown considerable variations among results in reported emission rates for various sources (Howard-Reed et. al., 2007). The situation is slowly improving; but in current practice, the reporting of uncertainty is generally voluntary, dictated solely by customer requirements. In fact, the standards that specify acceptance criteria for VOC emissions ignore the impact of measurement uncertainty on pass/fail determinations and simply state the criteria as absolute numbers not to be exceeded.

The uncertainty associated with a claim of product compliance is not limited to laboratory measurement uncertainty. Many manufacturing parameters, both systematic and random, contribute to product VOC emissions variability. For example, there may be multiple suppliers of component materials, significant production processes variations across assembly lines or plants, introduction of customer-specified materials such as furniture upholstery, or use of uncharacterized recycled materials that are potential VOC sources, etc. These variations are manufacturer and product specific. Variations in VOC emissions for products at the manufacturing level have received sparse attention in the literature. A study done by Magee et al. (2003), examined variability in a series of samples of oriented strand board (OSB) tested using standard chamber test protocol. The variability in VOC emissions from these samples was found to be significant (exceeding the analytical uncertainty by an order of magnitude in certain cases). The almost complete lack of information on manufacturing variability makes it difficult to even estimate the scale of the potential uncertainty.

## CONCLUDING RECOMMENDATIONS

### Proposed solutions

The current situation of uncoordinated independent standards can be improved if a more consistent set of rules is followed when developing standards. Consensus standards produced by ASTM or an ANSI accredited standard developer are governed by organizational requirements (e.g., ANSI, 2010). There are situations where standards and codes may be developed by organizations that are not official standard developers. Adherence to due process requirements such as established by ANSI (*ibid*.) is a best practice and would enhance the credibility of even unaccredited standards. The potential downsides of a full consensus process are longer development times and excessive compromise leading to watered down,

less science-based requirements. Nevertheless, there are common-sense guiding principles that should help any organization focus the development process for product and building standards and codes and may contribute to better coordination among standards (Table 2).

Table 2. Best-practice procedures for development of VOC emission standards

| Number | Recommendation |
|---|---|
| 1 | Engage all relevant stakeholder interests early in process |
| 2 | Clearly & accurately state objectives in scope |
| 3 | Rely on best scientific knowledge; seek participation & review from experts |
| 4 | Stay within field of expertise; reference accredited standards where possible |
| 5 | Reference authoritative sources, e.g., government health guidance |
| 6 | Require all parties to be responsible for quality |
| 7 | Be complete & transparent to reduce ambiguity in application |
| 8 | Reduce conflicts of interest & dominance by specific interests |

Figure 1 shows that laboratory testing of emissions is only one part of the process needed to establish a valid claim with respect to a product's VOC emissions. A best practices framework for VOC emission claims can be found in standards developed by the International Standards Organization (ISO). The relevant ISO standards cover the general principles of environmental labels and declarations (ISO 14020, 2000) and self-declared single-attribute claims (ISO 14021, 1999). The latter also is directly relevant to certified claims as many of the single-attribute claims covered in this standard can be, and frequently are, made using a third party.

The CDPH Standard Method (2010) references ISO 14021 and devotes a chapter to guidelines for making product claims. Table 3 lists key recommendations specified in the CDPH method. These guidelines provide a basic framework for extending test results to products, although considerably more needs to be done to define the details and requirements for the various industries and manufacturing situations.

Certificates for either certified or self-declared claims should clearly identify: 1) the product(s) that is covered noting any exceptions; 2) the standards used to establish the claim; 3) the place(s) and date(s) of manufacturing; 4) the test(s) upon which the claim is based listing the laboratory and the date(s) of testing; and 5) specific details such as the modeling scenario(s) used to determine compliance. In addition, more rigorous guidelines than currently provided by ISO Guide 65 are needed to ensure that competing certification programs operate in a fully transparent and consistent manner.

Table 3. Recommendations for extending VOC emission test results to product claims

| Number | Recommendation |
|---|---|
| 1 | Claims shall be accurate, verifiable, & updated if circumstances change |
| 2 | Certifiers, at minimum, shall operate in accordance with ISO Guide 65 |
| 3 | Manufacturers & certifiers shall have written product sampling plans |
| 4 | Samples shall be selected randomly from production lots offered for sale |
| 5 | Samples shall be selected from product groups or lots that are expected, based on evidence, to give worst case results |
| 6 | Claims may extend to groups of products provided models share same production methods & ingredients |

There needs to be better guidance regarding the proper activities and roles of the parties. Second parties, that are industry trade groups, may own, manage and promote an

environmental label for benefit of members, but should not put themselves in a conflict of interest situation by operating a laboratory or acting as a certifier. Third parties that are laboratories and certifiers should not engage in product compliance consulting. The marketing of compliant products should reside with the first and second parties, not third-party certifiers.

Procedures are currently being developed with respect to uncertainty to help laboratories create uniform uncertainty budgets for emission testing; however, no guidance currently exists for practically assessing uncertainty at the product manufacturing level. Proper balance between more comprehensive sampling/testing and cost must be considered when developing these uncertainty assessment procedures. Recommendations for the longer-term solutions for assessing overall uncertainty are as follows:

1. For laboratory VOC measurement uncertainty: apply ISO GUM method and continue current work of ASTM D22.05; quantitatively specify relevant uncertainty budgets in "Laboratory Test Method" section(s) of VOC emission standards.
2. For uncertainty associated with product specimen variability: conduct more research (or controlled tests) to identify sources of manufacturing variability and estimate magnitude of potential effects; qualitatively describe relevant uncertainty budget requirements in "Product Sample Selection, Collection and Handling" section(s) of VOC emission standards.
3. Define acceptable measurement confidence interval (i.e., 95% confidence interval) associated with pass/fail evaluation criteria instead of simply stating criteria as absolute numbers in VOC emission standards.

The current deficiencies in emissions testing will only be solved through the collaboration and cooperation of the major stakeholders, applying good science, and sound business practices.

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