DEVELOPMENT OF GUIDELINES FOR HEALTHY HOME CONSTRUCTION IN THE UNITED STATES AND CHALLENGES FACED IN THE PROCESS

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ABSTRACT
In the past decade the general population in the USA has developed a heightened awareness on indoor air quality (IAQ) issues. As a result there is a significant demand by the public for housing provisions that offer not only a comfortable living environment, but also one that is more conducive to improved health afforded by the quality of the indoor air environment. The American Lung Association (ALA) in the United States is responding to the needs of homeowners by undertaking the development of guidelines for builders, designers, and other members of the construction community, with the end-goal to provide guidance on construction practices for improved IAQ in residences. The guidelines are intended to address construction practices targeting homes for the general population and include a second tier of criteria for people with severe allergies or asthma. This paper details some of the issues and difficulties encountered in the formulation of the guidelines.

INDEX TERMS
Home construction practices, Moisture control, Builder's guidelines, Asthma and allergies

INTRODUCTION
People with asthma and allergies searching for relief from common allergic symptoms are paying increased attention to residential indoor air quality(IAQ). This interest is also shared in the overall population due to a heightened awareness of IAQ issues, and subsequent insistence for a healthier work and home environment. As a result there is a significant demand by the public for housing provisions that offer not only a comfortable living environment, but also one that is more conducive to improved health afforded by the quality of the indoor air environment. The American Lung Association (ALA) in the United States is responding to the needs of homeowners by undertaking the development of guidelines for builders, designers, and other members of the construction community, with the end-goal to provide guidance on construction practices for improved IAQ in residences, under a nationally sponsored ALA Health House™ Program. The guidelines are intended to address construction practices targeting homes for the general population. They will include a second tier of criteria for homes built for people with severe allergies or asthma. The work to develop a uniform Health House program (to include regional variations based on climate) presents a significant challenge. A Technical committee comprised of 19 professionals of select expertise was formed for the purpose of creating the guidelines. This paper is a summary of the deliberations, frustrations and ministrations of the technical committee and the guidance being developed from that effort.

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METHODS

Invited members to the technical committee expertise include building science, architecture, engineering, public health, medicine, microbiology, chemistry, industrial hygiene and residential construction. The committee met in Washington,DC, in December, 2000 to discuss the framework and content of the guidance. Previous home construction guidance formulated by lung associations and other various entities across the US was carefully scrutinized and discussed. At the end of two days, there was agreement on many issues, with others left to be decided after further deliberation. A committee member was charged with gathering the notes and developing a first draft for review. The draft was sent out to the committee members, comments received, and incorporated into the guidance as best possible. With each round of review the guidance has been made stronger, cleaner and more widely applicable. As of February 2002, the guidelines are in the final phase of review by the technical committee, and are soon to be submitted to the American Lung Association Program Board overseeing the Health House™ efforts.

RESULTS

The current draft of purpose and scope from the guidance is as follows:
"This document provides general guidance for builders subscribing to the American Lung Association's National home program to improve indoor air quality in newly constructed homes. Guidance has been developed for two levels of effort. The level "one" guidance has been developed for those in the general population seeking a healthier living environment. Level "two" criteria have been added to address some of the concerns that are more pertinent to those suffering from severe allergies or asthma. Each criteria in the document is labeled one, or two. Items labeled "one" must be adhered to for a Level One house. A Level Two house must conform to those labeled "two". In addition, the "one" rating automatically applies to the "two" rated home unless otherwise indicated.

Note that these criteria have been developed as general guidelines that must be met by builders enrolling in ALA's home program. They are not intended as all-inclusive of details that are to be followed for the home construction. Builders' guidance for targeted climates in the United States will accompany this document (to be developed) to detail the specifics of how the builder can meet the requirements of this program.

The guidance is currently organized hierarchically with main topic areas that largely parallel the construction process.

1) Site
2) Envelope
3) Finishes and Furnishings
4) Mechanical Equipment
5) Commissioning
6) Occupational Health and Safety

Each topic is further organized by sub-topics that also roughly divide along the lines of the construction process. This organizational scheme was selected based on familiarity with these items, being that the primary end user will be residential builders. The guidance itself is a list of requirements, followed by a rationale for the requirement. References are included that form the basis for the rationale or provide further information on methods for implementing the requirement.

While the guidance is being organized along the lines of the construction process, each section is also based on the principles underlying the epidemiological triangle - affected person, source of hazard and exposure mechanism. The following six step list of objectives was used as a model to address these items in buildings:

- Educate designers, builders and occupants in terms of indoor environmental hazard sources and interventions;
- Keep the buildings dry, clean and pest free (while minimizing the use of cleaning products and pesticides);
- Reduce potential contaminant sources;
- Provide exhaust for the fixed potential contaminant and moisture sources;
- Provide dilution ventilation for contaminants released by sources that cannot be fitted with exhaust ventilation (occupants, their activities and large surface area sources like floor and wall coverings);
- Reduce unintentional airflows that transport air from areas with potential contaminant sources into occupied areas (e.g. airflow from garages into living quarters, from the soil into the building or from combustion devices into the building), or sources of water vapor to cool surfaces (indoor air into unconditioned attic spaces during heating conditions or outdoor air into spaces chilled by air conditioning or earth contact during cooling conditions)

DISCUSSION

The entire program is based on education. Builders, architects and engineers will be able to participate in a training program to learn how and why the guidance is to be applied. Potential buyers will be educated by marketing efforts that highlight the Lung Association Health House™ program features. The following is a discussion of some of the issues that the technical committee has addressed within the guidance.

Dry, Clean, and Pest-free

Approaches to keeping the building dry, clean, and pest free are emphasized in the guidance to lower contaminants of biological origin, contaminants that are tracked in, and contaminants contained in cleaning products and pesticides.

Methods to keep the building dry focus on the following:

- excluding rainwater from the upper portion and foundation of the building;
- keeping water vapor-laden air from coming in contact with surfaces that have been chilled by cold outdoor air, air conditioning or refrigeration equipment, or contact with the cool earth;
- selecting and locating plumbing lines and equipment to make identification and repair less difficult; and,
- preventing ground water (or backflow from public disposal systems) from entering the foundation.

Moisture control requirements are drawn from a number of sources including the Builder's Guide series (Lstiburek, 1999), Canadian Mortgage and Housing Corporation Guidance (CMHC, 1994), and the SMACNA Architectural Sheet Metal guide (SMACNA, 1995).

Work conducted by Roberts (1998) highlights the importance of contaminants that are tracked in. Tracked-in contaminants are intended to be controlled by providing track-off systems at each entry and by designing the main entry to be a place where people may easily remove and store shoes and boots. Pest species avoidance measures are being addressed by a combination

of exclusion and making the indoor environments unwelcoming. Barriers to pest entry incorporate use of components of the building envelope, protecting vulnerable materials and sealing gaps and joints. Sealing methods rely on copper wire mesh for openings that are intended to allow ventilation or vapor relief; foam or caulk reinforced by copper mesh are utilized for openings that must prevent pest entry, air leakage, airborne contaminant transport, water vapor migration and fire control. Because so many control elements come to bear in the envelope, it is crucial that envelope design and materials are considered systematically. To contribute to dust mite control, and yet protect from scalding, it is proposed that hot water be delivered to washers > 54 degrees C and to sinks at < 43 degrees C, through use of a flow regulator attached to the hot water heater. Many of the moisture control principles and measures also contribute to a building that is inhospitable to pest species. Details of the pest control program are based on the published work of Dr. Stephen Frantz (Frantz, 1991).

Ventilation

The committee recognized the importance of proper dilution ventilation. Ventilation not only dilutes pollutants that originate indoors. Ventilation also limits the time for reactions to occur among gas phase pollutants -- the higher the ventilation rate, the less time gas-phase pollutants have to react with one another. Dilution ventilation is to be provided (where passive or "natural" ventilation is not adequate) by using controls that automatically operate an exhaust fan or outdoor air equipped central heating/cooling system fan. Effective distribution of the ventilating air is an integral part of the design. Non-fan powered or hybrid system may be substituted for fan powered ventilation provided modeling can show it will meet the ventilation performance criteria. Combustion equipment, dryers, ranges, bathrooms and kitchens all produce or harbor air contaminants. The guidelines currently state that combustion equipment be power vented or sealed combustion, making them very resistant to accidental spillage of fumes into the dwelling. Dryers should be separately vented; kitchen ranges are to have exhaust hoods; bathrooms to have low noise, efficient exhaust fans. All vents should be routed to an exterior outlet of the house. Proper filtration is also addressed in the current draft guideline with a minimum recommendation of 30-35% dust spot efficient filters (MERV 8) in homes targeting the general population, with additional filtration requirements for level two (allergy and asthma) population.

Difficult challenges in developing the guidance

The most difficult issues to address were:

- Wall-to-wall carpeting
- Volatile Organic Compound (VOC) emissions from building materials
- Contaminants from sources brought in by occupants
- Non-fan powered ventilation
- Contaminants originating in garages
- Methods of establishing compliance
- Including crawlspaces within the conditioned envelope
- Accommodating different climates

A brief discussion on a few of these issues is included here:

There was strong support among committee members for no wall-to-wall carpets. This position was based on the particle dynamics of carpet, VOC emissions, field experience with moisture problems in carpets over concrete slabs on earth and clinical experience from the medical community. Many on the committee did not feel that new carpet and related VOC emissions was a primary concern but rather the issue had more to do with the potential for

microbial growth (because of the availability of residual nutrients, and possible moisture accumulation), particle retention and re-suspension (especially with older carpets that are not properly cleaned or maintained). Some members of the committee with expertise in the construction industry made the argument that no carpeting would be a difficult item to sell in the marketplace. Eventually, the decision was made to include carpets (in the present draft) with a number of colateral requirements to address the particle, VOC and moisture issues.

Committee members agreed that VOCs released by building and finishing materials should be minimized. The challenge was to be able to provide simple guidance for builders to follow. Manufacturers change the compound formulations, and processes used in the manufacture of their products, on a continuing basis. Trace contaminants often appear in products but do not appear on Material Safety Data Sheets. The chemistry of the indoor air environment and subsequent reactions that may occur with outdoor air contaminants, pose additional concerns especially in areas of ozone nonattainment. A number of indoor air problems in the past few years have been traced to ozone or water reacting with compounds contained in manufactured products. The guidance draws from the works of a number of researchers pertaining to emissions from building materials, and indoor chemistry (Hodgson, 1999; Kelly, *et al.,* 1999; Levin and Hodgson, 1996; Shaughnessy and Weschler, 2001; Weschler and Shields, 1997). While much of the guidance specifies the careful selection of products and building materials based on lowest potential for emissions, the technical committee realizes the importance of providing builders with more practical guidance on selection of products and related VOC emissions. More work is slated under the Health House Program to address these concerns in the future.

The guidance proposes fan powered ventilation as the most robust way of ventilating homes, but allows for non-fan powered ventilation if it can be demonstrated by modeling or measurement that it provides the required amount of ventilation with the required frequency. Frequency of ventilation is important when there is the possibility of chemical reactions contributing to airborne contaminant loads.

Garages are the source of a number of contaminants, which often migrate into the residence, or are inhaled by people while in the garage. Detached garages are significantly more expensive than attached garages and do not avoid exposure to people *in* the garage. The increasing use of remote start devices for automobiles (an auto running in a closed garage for extended periods of time) may pose a serious concern for homes with attached garages. Using a physical barrier approach to this problem requires special attention to air-sealing, advanced fan pressurization testing to verify compliance and can be easily overcome by occupants making holes or propping doors opened. The option is fan-powered interventions to manage pressure relationships or to dilute contaminants generated in the garage; however, this approach may be prohibitive based on add-on cost to the home.

Crawlspace design was another area of prolonged discussion with no clear consensus reached within the committee. There exists evidence that if rain and groundwater are kept out, sealed crawlspaces with perimeter insulation hygro-thermally outperform ventilated crawlspaces (Lstiburek and Carmody, 1993; Rose, 1997). The guidance presently allows for either vented or sealed crawlspaces, but contains collateral requirements to deal with the problems intrinsic to each approach.

CONCLUSIONS

The technical committee assembled on behalf of the American Lung Association Health House™ Program has produced an imperfect, but thorough and useful guidance in its current draft form. A model, consistent Health House Program has the potential to impact the way that homes are built in years to come and provide a healthier living environment for allergy sufferers, children, and the general population. . Whereas there will always be some issues that prompt debate as to what constitutes "best practices" to achieve the desired goal, these guidelines are intended to provide the best consensus guidance at this point in time given our current state of knowledge. For more information on ALA's Health House™ Program visit the website at www.HealthHouse.org .

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