Principles, experiences and new developments of the emission classification of building materials in Finland

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ABSTRACT

A very important issue for all activities for better IAQ in Finland has been the introduction of the classification guidelines for indoor air quality and climate. These guidelines, published by FISIAQ, including measurable target values, cleanliness requirements and emission criteria for building materials, have been in use in Finland since 1995 and were revised in 2001.

An essential part of the successful IAQ classification has been the emission classification of construction materials. The number of building and finishing materials accepted and labelled to the best category, emission class *M1*, has already exceeded 600, providing a wide selection of products covering all the major types of building materials. The scope of this classification has been widened in 2001 to the cleanliness classification of ducts and other components of ventilation systems.

To improve the IAQ in real conditions in a building also other sources of emission, than the construction materials and ventilation, must be under control. Such common sources of harmful emissions are often the furniture, which are often strong source of chemical emissions, when new, and the various chemicals used for the cleaning, waxing and other treatment of the indoor surfaces, especially floors, in the buildings. Therefore, in Finland the emission classification of these substances is planned to begin in 2003, with special testing requirements and emission criteria meant for this purpose. Principles for these new planned requirements and criteria will also be presented and discussed in this paper.

INDEX TERMS

Product labelling; Material emissions; Policy; VOC; Sensory tests

INTRODUCTION

Many actions have been taken to improve indoor air quality (IAQ) in recent years in Finland. One very important activity for better IAQ in Finland has been the introduction of the classification guidelines for indoor air quality and climate. These guidelines, published by FISIAQ, including measurable target values, cleanliness requirements and emission criteria for building materials, has been in use in Finland since 1995 and revised in 2001 (FISIAQ, 2001; RTS, 2001). This Finnish classification of IAQ and building materials has proven to be a well functioning system and the classification guidelines have been well adopted by the building industry and are—although not mandatory—generally referred to in design and construction contracts in Finland. Buildings with measurable better IAQ have been built (Tuomainen *et al.*, 2000). The Finnish classification of IAQ and building materials has proven to be a well functioning system. It has clearly shown that private voluntary actions by the industry itself can essentially help in improving IAQ in buildings (Neuvonen, 2000, Kukkonen *et al.*, 2002).

An essential part of the successful IAQ classification has been the emission classification of construction materials. First, it was aimed only for finishing materials, but beginning from the year 2001 all construction materials could get the emission classification. The number of different construction and finishing materials accepted and labelled to the best category, emission class M1, has already exceeded 600, providing a wide selection of products covering all the major types of building materials. The essential portion of the most common finishing materials, paints, parquets, other flooring materials and adhesives, manufactured, sold and used in Finland, have already achieved the M1 label and the interest for the emission labelling is growing also among the producers of other than finishing materials.

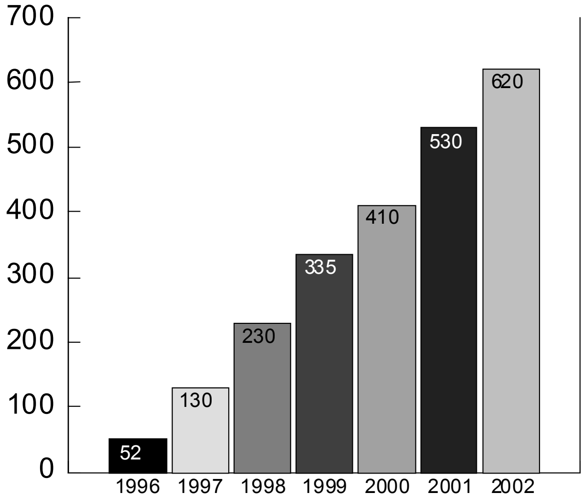

Figure 1 The M1 label for building materials.

Figure 2 The development of the number of M1 classified construction materials in Finland.

The scope of the material classification has been widened in 2001 to the cleanliness classification of ducts and other parts of ventilation systems. Many manufacturers of the ventilation components have already got this cleanliness classification label to their products. Widening of the classification also to other important sources of emission in the buildings has also been planned. The problems connected with the principles and practices with this procedure will be discussed in this paper.

PRINCIPLES OF THE EMISSION CLASSIFICATION

To avoid harmful emissions to indoor air and to build a house with good IAQ, all building materials and specially the finishing materials must be selected so as to keep these emissions under control. Therefore, the use of category M1 materials is necessary for achieving the best indoor climate category *S1*. Unfortunately, the use of only low-emitting materials does not always guarantee good air quality in rooms. Ventilation also has to be adequate and the materials should be used according to the manufacturers' specifications. For example, very few materials can tolerate being exposed to excessive moisture. Materials should also be easy to keep clean.

In the development of the Finnish classification system it was seen that the requirements for the emissions must as much as possible be based on well-known, if only possible internationally accepted, testing methods. So the requirements are set to the total VOC emissions, TVOC, instead of tracing the most harmful chemicals. These TVOC requirements are however complemented with the requirement to identify the most relevant VOC components, 85% of the highest peaks in the spectrogram. Also, the complementary sensory tests will certify that all essential harmful and odorous chemical components of the emissions will be detected by this method (Saarela *et al.*, 2002, 2003).

In the Finnish material emission classification system the category M1 is designated for materials which fulfil the following requirements:

1. the emission of total volatile organic compounds (TVOC) is below 0.2 mg/m^2/h;
2. the emission of formaldehyde is below 0.05 mg/m^2/h;

3. the emission of ammonia is below 0.03 $mg/m^2/h$;
4. the emission of carcinogenic compounds is below 0.005 $mg/m^2/h$; and
5. the material is not odorous (dissatisfaction with the odour is below 15%).

The chemical testing methods are based as much as possible on internationally accepted or used procedures and international ISO and CEN standards. The sensory tests are carried out by naive sensory panels using a normal acceptability scale. The measurement of emissions should be performed when the material is in the final form in which it is used. It also important that the labelled materials have product specifications, which should present possible limitations for the use of the material and also requirements for the environmental conditions where the material is applied and used. A detailed description of the whole testing and accepting method can be found from RTS (2001) and from the home web site of RTS (Building Information Foundation; http://www.rts.fi).

The manufacturer of the classified material must continuously keep the high standard of their products and so a reliable quality control system for the production is essential and required for the labelling procedure. The classification committee of RTS has also a possibility and right to make controlling tests about the quality of the materials and products.

During 7 years since the classification was initiated, the manufacturers and importers of construction materials have improved the quality of their products so much that the measured harmful emissions have decreased drastically and even with the factor of thousand or more in some cases. The domestic, as well as foreign, firms have developed new products with lower emissions by using improved technology and cleaner receipts in production and by laying more emphasis on product quality control. When the manufacturers have realized that the costs of these tests are very low compared with the advantage in the marketing of their products with the label of M1, they are now taking part to a greater extent in the system.

RELIABILITY AND ACCURACY OF THE CLASSIFICATION PROCEDURE

The reliability of the whole procedure depends on the chemical and sensory tests done by the known, skilled and certified, or preferably by officially accredited laboratories. The testing methods used in the testing procedure are based on widely used and accepted scientific background, described in many standards and standard monographs. However, as only a limited number of specimens are tested, also the manufacturers' quality control is an essential requirement. The sample testing of M1-classified products by RTS is primarily intended to support the manufacturers' own quality control. It is also generally known that competing manufacturers test each others' products.

The common accuracy of the chemical tests will be, according to the references and experiences, about 20%. The probable error of the sensory tests in the classification using small two-step panels (5/15) has been calculated to have a risk of 10%. In every case the overall risk of wrong conclusions in the acceptance and classification of the materials seems to be sufficiently low and functional for this very practical purpose.

The principles of the accuracy calculations are presented in more detail in RTS (2001) and Bjorkroth and Kukkonen (2002).

RESULT OF THE CLASSIFICATION: ESSENTIAL REDUCTION OF THE EMISSIONS FROM BUILDING MATERIALS

The classification of indoor air quality and of the materials according to their harmful emissions has now been widely used in Finland for more than 7 years. The system has proven to function well in practice. Buildings with better IAQ, and also falling into the best category S1, have been built and enhancement of IAQ has been tested and noted. Although the better IAQ may require some extra cost, this has been limited to only some percentage of total building costs and very negligible when compared with the life-cycle costs and especially with the advantages better IAQ gives to the users of the building.

One important issue in this process is that the manufacturers and importers of construction materials have, during these years, improved the quality of their products so much that the measured harmful emissions has been lowered drastically and even for many decades in some cases. The domestic as well as foreign firms have developed new products with lower emissions by using better technology in production and cleaner receipts and by laying more emphasis on product quality control. When the manufacturers have realized that the costs of these tests are very limited compared with the advantage in the marketing of their products, they are now taking a more active part in the system.

In the emission tests carried out by the State Research Centre all measured emissions from the classified, M1 labelled, materials are essentially lower than the similarly measured emissions from other non-classified materials. For example, the TVOC emissions from classified PVC materials are only about 20% of the corresponding TVOC emissions from non-classified PVC materials; from the adhesives the corresponding relationship is even better by only about 5%. Generally, results from more than 1000 different measured construction materials the TVOC emissions from classified materials are only in average less than 10% from the emission level of the measured, non-classified materials. Similar positive results have been measured also concerning other emissions, e.g. formaldehyde and ammonia. More detailed results of this large comparison study is presented in Saarela (2003) and Saarela *et al.* (2003).

Similar positive development, essentially reduction of emission rates, has also happened in odour emissions, measured by sensory tests, from classified materials compared with emissions from non-classified materials and products.

CLASSIFICATION ALSO FOR THE CLEANLINESS OF THE VENTILATION

One major cause of the sick building syndrome is obviously poor ventilation systems incapable of delivering clean, fresh air into inside spaces. Dust, moisture, emissions and microbiological growth should be eliminated from various components of the systems. Often the ventilation systems do not working as planned and they may unfortunately even be sources of pollutants to the incoming air. Harmful emissions may originate from many different components in a ventilation system. For example, measurements have shown high emitting components to be filters, humidifiers, heating and cooling coils and also parts of the ducts, especially used duct liners, neoprene gaskets, duct connectors and duct sealant. Even sheet metal ducts fabricated with lubricating oils have considerable, especially sensory, emission rates. Many times the new components are not cleaned enough after the manufacture and the surfaces can become coated with oils or chemicals, which can pollute the air.

Four years ago in Finland was established a large Clean ventilation project as a part of the Healthy Building Programme to study the reasons and mechanisms of this pollution from the ventilation system and to develop better technical solutions with less emissions (Rantama, 2003). This Clean ventilation project, which lasted 4 years and ended in 2002 not only focused on the development of new, less polluting, components, but also on the development of practical tools and guidelines for designing and installing clean non-polluting ventilation systems. New and comprehensive guidelines for designing and constructing cleaner ventilation systems have been published. New methods for cleaner cutting and installation practices of ventilation ducts have been developed and tested in practice. Furthermore, new, more reliable, but still cost-effective methods for testing and verifying the cleanliness of ventilation ducts and other components, or the whole ventilation system, have also been developed in the project. Moreover, the manufacturers of ventilation ducts and other components have considerable improved their products to achieve the cleanliness demands.

As one very important result of the Clean ventilation project, new test methods to define the cleanliness of ventilation ducts and other components were developed. These requirements were also used as a part to the Finnish classification system and the cleanliness classification of ventilation ducts and components were introduced in 2001 as a part of the material classification system. The requirements and the test methods are described in RTS (2001) and Björkroth *et al.* (2002).

FURNITURE AND TREATMENT CHEMICALS; WIDENING OF THE EMISSION CLASSIFICATION

The widening of the emission classification of construction materials must however be seen necessary, because so many emission-related IAQ problems have still arisen in the last years. Often there are problems with the office and home furniture; tables, desks, book-shelves, chairs, cabinets, closets. These often have in the beginning high emission rates due to the volatile chemicals used in the painting or lacquering of the piece of furniture. Normally the furniture has also been kept stored in a tight wrap before the transportation and installation and so the emissions have not declined before the installation and use. The decrease of the harmful emission during the use below the accepted, not harmful, level will in many cases take months. A sufficient solution could be the use of less emitting finishing materials or that the new furniture has been kept unwrapped and aired separately for some weeks or months before the installation to the permanent place.

Other common sources of high levels of harmful chemical impurities in the indoor air in homes, offices, schools, etc., are the high emissions from many treatment chemicals; cleaning chemicals, waxes and other treatment substances for the floor and other surfaces of the room. The harmful emissions from these substances will normally decline in some days or weeks, but because the treatment must and will be repeated periodically and quite often, the levels of the harmful chemicals in the room air will too often be unacceptably high.

The emission classification of above mentioned two groups, furniture and treatment chemicals, is now seen as a task for the Finnish emission classification. The setting of classification criteria in these cases is however not easy, due to the special characteristics of these sources. The size of the furniture is often, normally, too big for the normal testing chambers used for construction materials. The tests by other methods, e.g. small FLEC cells, are possible, but often not enough representative due to the complicated construction of the furniture, which are often assembled of many parts with different emissions. So it seems practical to accept the whole piece of furniture only if it consists and is made only of such pieces and materials that have been tested and M1 classified.

The chemicals used for cleaning, waxing or other treatment of the floor and other surfaces in the room cannot be classified using the same requirements as the normal finishing materials. These are used in the building surfaces quite frequently, often weekly or monthly, and their emission rates must decline therefore very quickly under the level of acceptance. The declining period of 28 days for the emissions used for normal construction materials (RTS, 2001; Saarela *et al.*, 2003) is not at all acceptable in this situation. It is now proposed that the decision about the acceptability of these materials could be relied only on the tests after 3 days and the emission rates should decline in this time below the acceptance levels used for construction materials.

The classification acceptance criteria for furniture and the treatment chemicals are however not yet officially chosen and decided. No formal decision has been made yet, but it seems now very probable that the classification committee of RTS in Finland will make the decision in 2003 following the ideas and principles presented above.

CONCLUSIONS

The Finnish classification of IAQ and building materials has proven to be a well functioning system. Especially the emission classification of materials and M1 labelling has been a success in Finland. It has essentially given impetus to the manufacturers to develop better, less emitting materials. This development and production of less emitting materials has also proved to be economically profitable.

The whole IAQ and material classification has shown that private voluntary actions by the industry itself can essentially help in improving IAQ in buildings. Government co-operation and support has also proven to be important and the aim to avoid unnecessary regulations has succeeded. When rewriting the IAQ quality requirements in the Finnish Building Code the value of good IAQ for the people and for sustainability of buildings will be even more emphasized. However, there are no plans to set limits on the emissions from building materials in Finland, because the harmful emissions are already being reduced now by voluntary means, especially due to this classification.

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