Classification of Indoor Environment 2018 and Updated Criteria of RTS Environmental Classification

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Abstract. The Finnish Society of Indoor Air Quality and Climate (FiSIAQ) introduced over twenty years ago in 1995 a Classification of Indoor Climate, Construction Cleanliness, and Finishing Materials. After two revised versions, the fourth edition Classification of Indoor Environment was published on May 2018. Based on the criteria set in the classifications, The Building Information Foundation RTS sr started M1-labelling of building products in 1996, named Emission Classification of Building Materials and Cleanliness Classification of Air-handling Components.

Indoor air quality and instruments in improving all the sectors to concern are in great importance in Finland. First part of The Classification of Indoor Environment 2018 (CIE 2018) includes new Requirements for Technical Target Values. The other part, Guidance for design and Construction, includes surface structural design, construction site design, Classification of Construction and Construction Work Cleanliness (P1), Classification of Building Materials (M1), Cleanliness Class of Air-handling components (M1) and instructions for designing mechanical systems for buildings.

The main changes in the 2018 edition are revised target values for indoor operative temperature, inclusion of a PM2.5 criteria, revision of some acoustical target values and revision of recommended outdoor air flows. Regarding thermal comfort, the target values of the individual indoor climate, S1, will be slightly more demanding than the targets of the S2, good indoor climate, class. The criteria for particulate matter, PM2.5, has been included due to the significant health impact of fine particles. The targets for acoustic environment in offices have been revised to reflect the importance of speech transmission. The recommended outdoor air flows follow the principles of EN15251-2007, considering the common usage of very low-emitting M1-class materials in Finland. The outdoor air flow rates have also been aligned with the recently changed building code values.

Companies have developed low-emitting building materials, fixtures, furniture and HVAC-devices during the years to meet the requirements. There are almost 5200 M1-classified low emitting building materials, fixture, furniture and HVAC-devices at the moment (May 2019). The Classification of Indoor Environment 2018 (classes S1, S2) and sub-classifications (P1) and (M1) are integrated part of the new Finnish environmental classification system for building processes called RTS Environmental Classification launched in the spring 2017 and updated in September 2018.
The Classification of Indoor Environment has been used in multiple office and residential construction projects during the years. By integrating the CIE 2018 requirements to the RTS 2018, third-party audit and certification of the whole construction project is possible. Therefore, the continuous improvement will be one considerable option.

1. Introduction

High indoor air quality is recognized as a crucial issue of both national health and economy in Finland. There are several projects and programs going on to ensure and excite to improve good indoor air quality and moisture management in building projects.

The Finnish Society of Indoor Air Quality and Climate (FiSIAQ) introduced twenty years ago in 1995 a Classification of Indoor Climate, Construction Cleanliness, and Finishing Materials. The first revised edition, Classification of Indoor Climate 2000, was published in 2001 and the second edition Classification of Indoor Climate 2008 was published in 2008 and the third edition was published in 2018. Based on the criteria set in the classifications, The Building Information Foundation RTS started the M1-labelling of building products twenty years ago in 1996, named Emission Classification of Building Materials and Cleanliness Classification of Air-handling Components. The testing protocol is updated continuously (RTS).

The purpose of the Finnish Classification for Indoor Environment is to help the user, building owner, developer, and designer of the building to set the target levels for indoor environment. Based on current knowledge of health and comfort, the target levels specified in the classification describe safe indoor environment conditions, the quality of which exceeds the requirements set by authorities. Indoor climate issues are considered in the conventional construction project in the same way as other functional requirements.

2. Classification for Indoor Environment 2018

The Finnish Society for Indoor Air Quality, FISIAQ, has a leading role in indoor air improvement and especially in developing the Finnish Classification of Indoor Environment 2018, even though the publication is a result of co-operation of many organizations. The targets, requirements, and instructions of the classification shall be taken into consideration at all stages of the construction project.

The developer or subscriber chooses the target values for the indoor environment in collaboration with the design team. The target values are chosen for each construction project from the values presented in the section ‘Target values for indoor environment’, either by choosing all the values from the selected category or by setting individually considered values for various parameters.

In order to reach the desired result, the developer shall control design by explicitly recording the desired indoor environment targets and making them known to all of the designers. Each member of the design team shall take care that the decisions made concerning the selected indoor environment class are presented in the following documents: drawings, work specifications, the supplement to the construction contract, and the quality control plan for the construction site.

The Classification of Indoor Environment has three parts:

PART 1: The classification of indoor climate gives target and design values for thermal conditions, odour intensity, noise levels, ventilation and indoor air pollutants.

PART 2: Guidelines for design and construction including classification of cleanliness in construction, principles and procedures for the main stages of construction works.

PART 3: The Emission Classification of Building Materials contains target values for odours and emissions of the materials, fixtures and furniture and recommended maximum surface area of materials based on their emissions.
The content must be considered when setting targets in the Green Leadership Tool.

2.1. PART 1: Target values for thermal environment and operative temperature in the CIE 2018

The following table (Table 1) presents the technical target values for thermal environment in the indoor air classes S1 and S2 which shall be used to specify the target level for indoor environment during the design phase of the construction project.

| Table 1 Target values for thermal environment, new and old criteria represented |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| **Operative temperature $t_{op}$ [°C]** | **New criteria S1 class** | **Old criteria S1 class** | **New criteria S2 class** | **Old criteria S2 class** |
| $t_{u} \leq 0$ °C | 21,5 $^{1)}$ | 21,5 $^{1)}$ | 21,5 | 21,5 |
| $0 < t_{u} \leq 20$ °C | 21,5+$0,15xt_{u}^{1)}$ | 21,5+$0,3xt_{u}^{1)}$ | 21,5+$0,2xt_{u}$ | 21,5+$0,3xt_{u}$ |
| $t_{u} > 20$ °C | 24,5 $^{1)}$ | 24,5 $^{1)}$ | 25,5 | 24,5 |
| **Deviation allowed from set value [°C]** | **Deviation upward** | **Deviation downward** | **Deviation upward** | **Deviation downward** |
| $t_{u} \leq 0$ °C | $\leq 22,5$ | $> 22$ | $\leq 23$ | $> 20,5$ |
| $0 < t_{u} \leq 15$ °C | $22,5+0,166xt_{u}$ | $20,5+0,075xt_{u}$ | $23+0,2xt_{u}$ | $20,5+0,025xt_{u}$ |
| $t_{u} > 15$ °C | $< 25$ | $> 22$ | $< 26$ | $> 21$ |
| **Maximum value of operative temperature [°C]** | $t_{op} + 1,5$ | $< 23$ | $< 23$ | $t_{u} \leq 10$°C: $t_{op} + 1,5$ |
| $t_{u} \leq 0$ °C | $23+0,2xt_{u}$ | | $23+0,2xt_{u}$ | $10 < t_{u} \leq 20$ °C: $23 + 0,4 \times (t_{u} - 10)$ |
| $0 < t_{u} \leq 20$ °C | $< 27$ | | $< 27$ | $t_{u} > 20$ °C: $27$ |
| $t_{u} > 15$ °C | | | | |
| **Minimum value of operative temperature [°C]** | 20 | 20 | 20 | 20 |

A temperature control is essential for the indoor environment. In the updated classes S1 and S2, the temperature must stay within target value range 90% of the operating time. There is an exception in the class S2 for residences where the temperature must stay 80% of the time within target value range. The content must be considered when setting targets in the RTS Environmental Classification. One third of the points in the tool can be gathered from indoor air related criteria.

2.2. PART 1: Indoor environment quality in the CIE 2018

Technical target values of the indoor environment during the use phase apply to the occupied zone of a room (with respect to the speed of air, 0.1 m from the workstation at an elevation of 1.1 m). It usually extends from the floor surface up to 1.8 metres and begins at 0.6 metres from the walls.

The carbon dioxide concentration target applies to carbon dioxide from humans. The stability of the conditions is observed with the fluctuating one-hour average for carbon dioxide concentration. The target concentration of the particulates is the average concentration in indoor air during 24-hour measurement. The radon concentration is determined by a measurement method approved by Radiation and Nuclear Safety Authority.
PM$_{2.5}$ particulate concentration refers to airborne dust in indoor air with particles having an aerodynamic diameter of less than 2.5 $\mu$m. The particulate concentration is measured according to standard SFS-EN 12341 during normal use of the building and the measurement lasts for 24 hours.

The relative humidity of the air has not been given a target value because it can be very low during freezing temperatures. When using local humidification, the relative humidity of the air should be below 60 % and humidification should not cause the risk of moisture and microbial damage. In humidifying the air, attention shall be paid to the humidifiers not increasing impurities in the air. The relative humidity of the air is measured with, for example, a psychrometer or capacitive sensor in accordance with the standard SFS-EN 12599.

Table 2 Target values for indoor environment quality

|                    | S1                    | S2                    | S3                    |
|--------------------|-----------------------|-----------------------|-----------------------|
| Additional* carbon dioxide concentration [ppm] | <350                  | <550                  | <800                  |
| Radon concentration [Bq/m$^3$] | <100                  | <100                  | <200                  |
| PM$_{2.5}$ [µg/m$^3$] | <10                   | <10                   | <25                   |
| PM$_{2.5}$ indoors / outdoors | <0.5                  | <0.7                  | –                     |
| Relative humidity [% RH] | –                     | –                     | –                     |

* Higher than the ambient carbon dioxide concentration.

2.3. **PART 2: Guidance for design and construction in the CIE 2018**

During the project design phase of the construction project, the developer /client / construction manager shall in co-operation with the design team determine and choose the target values related to indoor environment, construction cleanliness, and the emissions of building materials at the beginning of the construction project and shall make them known to all designers involved in the construction project.

In the project design stage, the indoor environment categories (S1, S2, S3) of space types central to the project programme are defined. In the proposed design, the targets are specified as individual target values. The chosen target values of the indoor environment and the related technical specifications shall be explicitly presented in all documents. The most crucial document from the standpoint of indoor environment is the contract limits appendix.

More detailed procedures are presented in the work specifications and instructions and obligations are presented in the contract documents. The contract limits appendix shall specify who is responsible for:

- schedules concerning (the drying out of structures before application of finishing materials the testing, adjustment and commissioning of mechanical systems; the required verification of cleanliness before the operation tests; protection of structures from the harmful effects of the weather)
- proper sealing of pass-throughs and joints in the structures
- on-site insulation of vibration and sound for vibrating mechanical units and pipes supported by the structures
- removal of water during construction phase so that the structures remain dry
- quality control plan of the construction site
- inclusion of the moisture control plan in the quality control plan of the construction site
- provision of clean and dry storage facilities for classified building materials and air-handling equipment, or corresponding arrangements
- premises for operational testing
- training the designers and contractors in mastery of the requirements of the classification

### 2.4. PART 3: New requirements of the Emission Classification of Building Materials

The classification of building materials has three emission classes, where emission class M1 corresponds to the highest quality and emission class M3 includes materials that don’t meet the requirements of class M2. The classification presents emission requirements for the building materials, fixture and furniture used in ordinary work spaces and residences with respect to good indoor air quality.

#### Table 3 Requirements for the classes M1 and M2

| Examined qualities                                                                 | M1-class [mg/m²·h] | M2-class [mg/m²·h] | Upholstered office chairs M1-class [µg/m³] |
|-----------------------------------------------------------------------------------|--------------------|--------------------|------------------------------------------|
| The emission of total volatile organic compounds (TVOC). A minimum of 70% of the compounds shall be identified. | < 0.2              | < 0.4              | ≤ 20                                     |
| Single VOC (µg/m³)                                                                | ≤ EU-LCI           | ≤ EU-LCI           | ≤ EU-LCI or ≤ 10                         |
| The emission of formaldehyde (HCOH)                                               | < 0.05             | < 0.125            | ≤ 10                                     |
| The emission of ammonia (NH₃)                                                     | < 0.03             | < 0.06             | ≤ 10                                     |
| The emission of compounds (CMR) belonging to category 1A or 1B in Annex VI to Regulation (EC) No 1272/2008 [mg/m³]¹ | < 0.001            | < 0.001            | ≤ 1                                     |
| Odour ²                           | Is not odorous     | Is not odorous     | Is not odorous                           |

¹ does not apply to formaldehyde
² The result of sensory evaluation shall be at least + 0,0

The committee of Indoor Air PT17 has an authorization to accept new criteria for the classes M1, M2 and M3. The PT17 accepted one new tighter requirement for M1-class for building materials on 5th December 2018. The new criterion for “The emission of compounds (CMR) belonging to category 1A or 1B in Annex VI to Regulation (EC) No 1272/2008 [mg/m³]” is 0.001, the former requirement was 0.005 mg/m³·h. In addition, there have been included single voc criterion where have been referred to the EU-LCI-list.

The new specific requirements and criteria of the classification of building materials concerns especially office chairs with paddings and textile coverings. The criteria vary from the common criteria of M1 because of the special character of upholstered furniture. When one aims for the best indoor environment category, S1, the use of materials with higher emissions (emission classes M2 and M3) shall be restricted. Upholstered office chairs can only be classified in class M1.

The new criteria for Emission Classification of Building Materials mentioned in the third part of the Classification of Indoor Environment has been set in the classes M1 and M2. The content must be considered when setting targets in the Green Leadership Tool. All the standards behind the Classification of Building Materials can be found from the protocol: M1 Emission Classification of Building Materials: Protocol for Chemical and Sensory Testing of Building Materials. One of the accepted testing laboratories is in the USA and the other in Europe, two of them in Finland.
3. Finnish Classification of Indoor Environment 2018 in the RTS Environmental Classification

RTS Environmental Classification is a system for managing construction process in a sustainable way. The system recognizes best national (Finnish) building strategies and practices. While there are globally accepted certification schemes, a need for national tool with local perspective and integration to local best practices like the Classification of Indoor Environment 2018, has been recognized especially in non-profit real estate sector as municipalities renovating and building schools, day care centers, health care centers and other social property. The environmental classification tool makes it easier to agree upon matters such as the energy efficiency targets of buildings and solution development.

The tool has been developed for the Finnish public real estate owners as municipalities, but it is suitable for all property owner’s despite of the background and business model. The classification was launched in the spring 2017 and there are 90 active projects and 140 users in the tool on May 2019. The RTS Environmental Classification follows the changes, developments and needs of the market, therefore the criteria will be updated continuously.

The Finnish Classification of Indoor Environment 2018 is mentioned in the following criteria: P3.2 Site dust management, S1.1 Indoor temperature, S1.2 Air quality, S1.3 User controls, S1.4 Material emissions, S3.1 Space acoustics, S3.2 Sound insulation. Although there are not specific requirements for air-handling components, it is assumed that there will be used M1-classified products like ducts, fittings, air filters etc. in the projects to achieve class S1 or S2 indoor environment conditions.

3.1. An example of the criterion S1.4 Material emissions

Low-emitting building products and furniture are essential part in achieving good indoor air quality. The assessment will consider all materials inside the building's vapor barrier, except for technical facilities that do not have direct contact with indoor areas (district heating substation, AHU-rooms, etc.) and products that are connected to indoor air. The low-emission of products is reported at the site phase with a list showing the name of the product, the manufacturer, target of use, and note of the emission certificates. The following certification marks and levels are approved for material emissions certifications: Emission class M1 for building materials, GEV Emicode EC1 and EC1Plus, Blue Angel, GUT. The criteria for low-emitting products include:

- Low-emission materials have been effective in significantly reducing the total concentration of harmful indoor pollutants.

Low-emission indoor materials, 50% of the weighted value:

1: Paints, adhesives, carpets and floor coating used inside the vapor barrier and wood panels meet the emission limits of materials.
- Designer: Recording of material requirements into contract documents.
• Developer: Summary of the used products and certificates
• User:

2: Fixed furniture is low-emitting or manufactured from low-emitted materials (adhesives and coatings)
• Designer: Requirements are recorded in the plans
• Developer: Fixed furniture certificate or sub-component list and certificates
• User:

3: The inorganic fibres must be shielded or encapsulated in all indoor spaces. In renovation, all existing unprotected fibre sources should be removed or encapsulated.
• Designer: Requirement to encapsulate the inorganic fibres
• Developer: Inspection lists for building components containing inorganic fibres
• User:

4: In renovation, contaminants (PAHs, creosote, asbestos) should be removed from the contract area
• Designer: Clarification of contaminants if construction year before 1990
• Developer: Inspection lists for removing contaminants
• User:

Room air quality is indicated by measurements, 50% of the weighted value:

5: Measurements made using approved measurement methods in the commissioning of a building indicate that total room air concentrations are on acceptable level before the use of the building.
• Designer: Measurement obligation is recorded in the contract material
• Developer: Measurement report
• User: Measurement report

Alternatively, low emissions can be demonstrated by verifying equivalence with the emission class M1 requirements for materials by an acceptable test method (EN 16516: 2017 + EN ISO 16000-9: 2006 + ISO 16000-28: 2012). Low-emission base materials such as concrete, natural stone, ceramic and crimped tiles, as well as untreated timber are approved directly and are not required to be certified. In renovation, it is assumed that all residual surface materials can be thought to be low-emitting in an existing situation.

Inorganic fibres include e.g. fibreglass (technical fibreglass) and mineral wool fibres. Mineral wool fibres are used in thermal insulation materials for exterior walls, ground and top floor structures, thermal, sound and fire insulation materials in ventilation ducts, in air filters and in room acoustic insulation materials such as acoustic boards and panels. As a protective measure is accepted e.g. coating, encapsulation, paint coating of open surfaces.

Requirements for indoor air total concentrations

Measurements are made as one-time measurements in type-specific spaces before users with ventilation already in use. The measured concentrations must be below the following limit values before use:

Formaldehyde ≤ 100 µg/m³, 30 min average
TVOC ≤ 1000 µg/m³, 30 min average

The concentrations measured during the operating phase must be below the following limits:
Formaldehyde ≤ 50 µg/m³, 30 min average
TVOC ≤ 200 µg/m³, 30 min average

Accepted measurement methods for indoor air concentrations

Measurements of concentrations should be made according to the following standards:
Formaldehyde: ISO 16000-3
TVOC: ISO 16000-5 and ISO 16000-6 or ISO 16017-1
4. Conclusions

Classification of Indoor Environment 2018 is intended for the setting of indoor air targets concerning usual work and occupied spaces as public buildings, schools, day-care centres and dwellings. The previous version Classification of Indoor Environment 2008 was widely used in construction industry and therefore the updated version is suitable for RTS Environmental Classification as well to help setting indoor air targets, controlling and helping design and material choices, helping water and moisture control planning and construction cleanliness as well as construction site design.

Companies have developed low-emitting building materials, fixtures, furniture and HVAC- devices during the years to meet the requirements for Emission Classification of Building Materials and Cleanliness Class for Air-handling Components. These classifications are included in the Classification for Indoor Environment 2018. There are almost 5200 classified low emitting building materials including 70 furniture and 370 HVAC-devices (May 2019).

There have been clear improvements also in construction technology and the use of buildings. Moisture management has improved in construction sites and designers have been committed to achieve the targets. Companies that have chosen to use RTS Environmental Classification for construction processes have noted that most important thing is that the tool concentrate on the most relevant issues, it considers Finnish legislation and northern climate and it will guide the process and help with material choices.

The RTS Environmental Classification will help construction industry in setting environmentally acceptable targets for construction projects when operating in Finland. The Finnish legislation and both indoor air and outdoor air circumstances have been considered. By including CIE 2018 requirements to the RTS the process and outcome can be certified after the project. We have a long tradition in Finland to cooperate and create together acceptable systems and the ability is even more important in the future because of the accelerating demand for sustainable methods and instruments.

5. References (some of them only in Finnish)

[1] CEN/TC 350 standards
[2] Classification of Indoor Environment 2018, Finnish Society of Indoor Air Quality and Climate, FISIAQ, Espoo, Finland (will be published on May 2019 in English)
[3] Cleanliness Classification of Air-handling components, The Building Information Foundation RTS sr, http://m1.rts.fi
[4] Emission Classification of Building Materials, The Building Information Foundation RTS sr, http://m1.rts.fi
[5] M1 Emission Classification of Building Materials: Protocol for Chemical and Sensory Testing of Building Materials, The Building Information Foundation RTS sr, http://m1.rts.fi
[6] HTP Values 2016: CONCENTRATIONS KNOWN TO BE HARMFUL, Publications of the Ministry of Social Affairs and Health 2016:8
[7] Green Leadership Tool Criteria 2018, The Building Information Foundation RTS sr, http://glt.rts.fi

Finnish legislation: (can be searched from www.finlex.fi by reference code (e.g 782/2017), some of them are described only in Finnish or Swedish)

[8] Decree of the Ministry of Social Affairs and Health on Health-related Conditions of Housing and Other Residential Buildings and Qualification Requirements for Third-party Experts (545/2015)
[9] Terveydensuojelulaki. Suomen säädöskokoelma 763/1994.
[10] Ympäristöministeriön asetus rakennuksen ääniympäristöstä 2017
[11] Ympäristöministeriön asetus rakennusten kosteusteknisestä toimivuudesta 782/2017
[12] Ympäristöministeriön asetus uuden rakennuksen energiatehokkuudesta 1010/2017
[13] Ympäristöministeriön asetus uuden rakennuksen sisäilmastosta ja ilmanvaihdosta 2017
[14] The National Building Code of Finland, Ministry of Environment, http://www.ym.fi/en-US/Land_use_and_building