BIMplement

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Report:	**D3.3 Elaborated quality control and qualification matrix for ventilation and air tightness as an example**
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Executive summary

The Deliverble D3.3 'Elaborated quality control and qualification matrix for ventilation and air tightness as an example' presents an overview of available and suitable quality control techniques and protocols allowing sufficient quality assurance in the area of air-tightness and ventilation. This report presents the most commonly applied quality control mechanisms used in this area in the different European countries where the BIMplement implementation will take place during the project duration: the Netherlands, Poland, Lithuania, Spain and France. This quality control procedures are linked with the qualification framework (QF) presented in earlier deliverable D3.1.

This final version of the report D3.3 presents an overview of the most commonly applied quality control techniques in the area of air-tightness and ventilation in the above stated countries. The initial idea was that in the second half of the project, for each experimental site the BIMplement implementation script should be elaborated and that it will be defined in detail the specific quality control mechanism brought in the specific project stages according to the project needs and its objectives (whether focus on improving air-tightness or ventilation).

However, during the second half of the project it was necessary to put the focus on solving the lack of BIM competences on the experimental sites. As a consequence, the BIMplement Model nZEB Cross-trade Quality and BIM-Skills Matrix, although fully in place, could not be actively used as a methodology. Nevertheless, the substantive quality aspects from the qualifications, developed in work package 3, were used in the training sessions and in the mobile training containers.

The BIMplement matrix (presented in chapter 1.8) still can be implemented and elaborated in detail for follow up trainings. This is important as the BIMplement approach and methodology is now actively being used and implemented in several new H2020 projects (for example in TripleA-reno, Save the Homes, re-MODULEES). In these projects it is used to determine the components and/or aspects which are due to quality control and in which phase in the project. Also, it is used to determine the professions/trades and skills that are needed and, linked to that, which competences the involved craftsmen should have (D3.1). In addition, trainings available on a national level (D3.2) to achieve the necessary levels of competences can be linked.

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1. Introduction to quality control methodology in BIMplement

1.1 Introduction

A good ventilation system is essential for a healthy and comfortable home. Together with a wind and watertight building envelope, the ventilation system is one of the basic elements of a home. At the same time, ventilation has a major impact on energy use. In total, about 9 to 10 % of the total energy use in Europe is spent on ventilation (both purpose provided ventilation, infiltration and support energy for ventilation.

However, many European studies show that in practice the ventilation system is the most frequently mentioned negative assessment aspect of homes, in terms of ventilation related complaints (poor indoor air quality, draft, noise, etc). This is often related to both a poor quality of design, installing of ventilations systems and improper operation and maintenance.

This was the reason to select ventilation and air tightness as the most interesting and relevant key points for BIMplement to develop the methodologies for BIM enhanced quality control.

The selection and implementation of a ventilation system is closely related to the energetic design of residential buildings, especially if the design is towards NZEB. That is why the total quality control must be considered as an integrated part of the total construction and integral design process (cross-time and cross-disciplinary).

1.2 Role of ventilation in residential buildings

What is Ventilation?

Ventilation is the process where (staled and used) air in a room is deliberately replaced by fresh air. This fresh air is mostly totally or partly obtained from outside. Ventilation is on the first place necessary from the point of view of health. It must provide the supply of oxygen, which is necessary for the metabolism, and for the removal of contaminated air. The decisive factor in this is the release of carbon dioxide by humans. In addition, moisture and odor production (such as cooking, washing, showering, etc.) is decisive in a number of rooms, such as toilets, bath rooms and kitchens, for the amount of ventilation required. A second role of ventilation is to avoid degradation of the building fabric (e.g. mold growth, rot in wood, rust on steel). Ventilation can also have other tasks such as the dissipation of heat and the supply of oxygen for combustion appliances.

Why Ventilation?

A good and adequate ventilation is necessary for a healthy and comfortable home necessity. However, good and adequate means in fact: on the right spot, on the right time with the right air flow. Poor indoor air quality can have a negative impact on health. This can vary from relatively mild health complaints, often only manifesting during the presence in the building, to more serious health effects that also manifest themselves in the longer term. A lot of different pollution sources can occur in a home. Ventilation is just one way to keep the indoor environment within acceptable limits. However, the main resource is *source avoidance*, followed by *source control*. In order to determine a good ventilation strategy, also taking into account energetic aspects, a coordinated approach is necessary. In order to guarantee all this, all national and international[1] standards and regulations on ventilation imposes a number of basic requirements on matters such as *flow rate*, *comfort, capacity of the ventilation air* and *direction of the flow*. In addition, requirements can be set for window airing. In practice, however, it appears that these requirements does not automatically lead to sufficient health and comfort if there is no quality control of the total process, from program and design to execution to operation and maintenance.

[1] CEN TC/156 has produced new European standards about ventilation in buildings (both residential and non-residential buildings). All the approved standards have automatically to be translated in national standards in each European country, and existing standards that are in conflict have to be removed. This has an influence on the work of the ventilation sector.
CEN/TC156 deals with all aspects of ventilation for buildings. The scope covers the standardization of terminology, testing and rating methods, dimensioning and fitness for purpose of natural and mechanical ventilation systems and components for buildings subject to human occupancy; it includes both dwellings and non-residential buildings. In addition, CEN/TC 156 work also covers work in the area of Fans, ventilation in hospitals and ventilation in commercial kitchens.

1.3 Air tightness and infiltration

In addition to air changes by purpose provided ventilation, unwanted air changes due to infiltration of air can occur through seams, cracks and other leaks in the building envelope. So there is an essential distinction in the sol called *conscious* ventilation or purpose provided ventilation and *unconscious* ventilation or infiltration. In case of conscious ventilation, the air changes are realized by means of specially designed ventilation systems and ventilation provisions which must be controllable and adjustable. In contrast, infiltration is uncontrolled and therefore often leads to discomfort (draft) and unnecessary energy use. For that reason, infiltration must be limited as much as possible by air tight building. The degree of infiltration is determined by the air tightness of the house or building. The airtightness of a house is atypical architectural and building technical property. The level of airtightness can be influenced by the way of detailing, the choice of materials and the execution. This is a decisive factor for the final quality level. The amount of ventilation as a result of infiltration depends on the degree of air permeability, the distribution of air leaks and the climatic conditions.

The degree of airtightness also determines to a large extent *the applicability* of certain ventilation systems. Therefore. when choosing a ventilation system or concept, the airtightness of a house or building must always be taken into consideration. For example:

- For MVHR systems the airtightness of the building should be at least $n_{50} < 0,5$. Moreover, dwellings with MVHR are more sensitive to cross ventilation, caused by infiltration.
- For single family dwellings with natural supply and mechanical exhaust the floor between the crawl space and the dwelling should be very well airtight to avoid transport of air from the crawl space to the dwelling (because of under pressure).

1.4 Quality, quality control and assurance, commissioning

The International Organization for Standardization (according to ISO 9000:2015: Quality management systems—Fundamentals and vocabulary) defines quality as ‘degree to which a set of inherent characteristics of an object fulfills requirements’.

Quality control (QC) is defined as ‘part of quality management focused on fulfilling quality requirements’. To put it more practical, it represents a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer.

QC is similar to, but not identical with, quality assurance (QA). QA is defined by the ISO 9000:2015 as a ‘part of quality management focused on fulfilling quality requirements’. Therefore, it presents procedure or set of procedures intended to ensure that a product or service under development (before work is complete, as opposed to afterwards) meets specified requirements. QA is sometimes expressed together with QC as a single expression, quality assurance and control (QA/QC).

While quality assurance relates to how a process is performed or how a product is made, quality control is more the inspection aspect of quality management.

Quality inspection are measures aimed at checking, examining, measuring, or testing of one or more product characteristics and to relate the results to the requirements to confirm compliance. Inspection can be easily done for tangible products (e.g. ventilation systems and its components), where in the area of air-tightness more elaborated quality control plan should be discussed during the earlier construction phases.

In relation to the term ‘quality control’ there is also the term ‘Commissioning’. Commissioning is defined as follows: ‘Commissioning is the process of ensuring that a building is in perfect working order and performing exactly as its designer intended and its owner/occupiers require’ or, conform ASHRAE 1996-1: the process of ensuring that systems are designed, installed, functionally tested and capable of being operated in conformity with the design intent. As in Anglo-saxon countries commissioning is limited to the control of specifications and performances in the hand-over phase, in EU commission is covering the control of total process: from the programme phase to the operation phase.

1.5 Quality control in the area of ventilation

The ventilation rate is commonly expressed as air flow rate in liters per second (L/s) or air change per hour (ACH).

Ventilation Rate Procedure is rate based on standard and prescribes the rate at which ventilation air must be

delivered to a space and various means to condition that air (for commercial buildings). For residential buildings, which mostly rely on infiltration for meeting their ventilation needs, a common ventilation rate measure is the air change rate (or air changes per hour). Air quality is most often assessed through CO2 measurement where sufficient inspection of the ventilation systems should be done following a particular applicable guidelines and protocols of a specific system. Furthermore, with advancement of the building automation systems (BAS), including techniques for HVAC monitoring, it is becoming easier to monitor the ventilation systems in buildings and therefore to ensure sufficient and desired air-quality levels indoors.

Ventilation components due to quality control

The most common components for mechanical ventilation are:
- Fans, as driving force for the mechanical ventilation.
- Ducts for air transport. Ducts impose resistance to air flow, thus influencing performance, energy use and also noise production.
- Diffusers, air inlets and exhaust grilles.
- Silencers (noise attenuators).
- Filters.
- Heat exchangers (in case of heat recovery). The most common type of heat exchangers in MVHR systems are counter flow heat plate heat exchangers.
- Sensors for demand controlled ventilation. Most common used for demand controlled ventilation are CO_2 and RH sensors.

The most common components for natural ventilation are:
- Air vents, trickle ventilators which can ensure that unnecessary ventilation can be avoided during winter. One vent per (habitable) room is typically installed. They are often located above the window or integrated into the window frame. Sometimes ventilators are located directly behind wall mounted radiators in order to avoid draft during winter.
- Controlled air inlets (for example by wind pressure, RH). These can be passive controlled inlets or active controlled inlets (by sensor controlled servo motors). These are more critical in quality control, especially in terms of maintenance.
- Passive stacks.
- Air vents for combustion appliances.

1.6 Quality control in the area of air tightness

Most European countries include in their regulations either required or recommended minimum airtightness levels with or without mandatory testing (for certain building types or in the case of specific programmes). The most common airtightness measurement is a fan pressurization test (a blower door) to pressurize the building which is also described in ISO 9972:2015.

1.7 Quality Control in BIMplement

Within BIMplement, the idea is that through implementation of the methodology developed in this project and using BIM as a communication carrier, the relevant actors will be upskilled sufficiently which will result in improved quality of nZEB construction and renovation. However, to test that the set quality requirements and targets are met, certain quality control mechanisms need to be applied during the project. It is important to identify the quality checkpoints already at the earlier project phases, not only in the Handover Construction and Close Out. In current practice, this is the phase when the quality is checked as part of Handover specification – building is certified and approved to be put in use by obtaining a sufficient certification.

However, if the errors and mistakes already appear and remain unnoticed during the earlier stages, this can lead to large costs and time delays if only discovered at the construction phase (e.g.: blow-door test showing insufficient air-tightness) or even worse, once building is constructed and put in use (e.g.: leakages, complaints when building already

occupied). Therefore, sufficient 'prevention' quality checklists are needed in earlier project stages to avoid jeopardizing realized quality in later stages.
With digitalization of construction industry, new innovative techniques are on the rise that can ensure high quality control and therefore sufficient quality realization. As example, object recognition via augmented reality (AR) during design (measuring and scanning), construction (during the execution process) as well as end-control Quality control in nZEB can be used.

1.8 Towards a Systematic Quality Control and Commissioning for ventilation systems - the BIMplement Model nZEB Cross-trade Quality and BIM-Skills Matrix

The BIMplement Model nZEB Cross-trade Quality and BIM-Skills Matrix is a structure for overall quality control for building services, and ventilation systems in particular. Its intention is to control the total production process including specifications, design, construction, hand-over and operation. It focuses on avoiding failures on all strategic aspects and moments in this process. It is an instrument for controlling the total process of making building services and can be applied for advanced ventilation systems and concepts (i.e. ventilation systems in relation to properties of the building and other building services . It contains all operational techniques and activities, necessary to realise a defined level of quality. The quality level has to be precisely formulated. In this framework "Quality" means that the delivered performance matches the required and precisely formulated requirements and expectations of the principal, including time planning, budgets as all technical aspects. The Quality Control should focus on:

- avoiding failings in all the phases of the process, starting with the programme phase up to and including the operational phase;
- assuring reliability in defined time intervals

In order to deliver a good final product the activities of all individual building partners as well as their skills (and skills levels) must be geared to one another. In all the phases of the process several activities will be carried out that have an impact on the quality of the final product. For example, a client is perhaps not able to formulate her/his requirements and expectations in the program phase. This leads to the risk that technical ideas are developed in the design phase and elaborated in the elaboration phase that will not be financial feasible or match with the overall expectations. Another risk is the development of technical ideas in the design phase that has a certain level of technical complexity. If the required skills of installers are not well defined there is a major risk of failures during the execution and the operation of the installation.
Quality Control in BIMplement (the 'Model nZEB Cross-trade Quality and BIM-Skills Matrix') is based on a general model that can be applied for all kinds of processes (building and building services, industrial etc.). Regarding HVAC systems it is possible to elaborate a Quality Control system for the total ventilation system or for separate elements (i.e.: heating, cooling, ventilation). The most important characteristic for the BIMplement Quality and BIM-Skills Matrix for ventilation systems is a structure that follows all the process phases. This enables to build in a number of strategic decision and quality control moments in the (construction or renovation) process and to assess if a ventilation system meets the targets and requirements, as defined in the program phase. As the total quality is determined by several aspects (not only technical but also financial, organisation and communication) 10 different quality control aspects can be discriminated.
This leads to the basis of the BIMplement Model nZEB Cross-trade Quality and BIM-Skills Matrix. On the horizontal axis of the matrix the phases of the process are distinguished. On the vertical axis of the matrix ten distinguished quality control aspects are listed.

		project phase				
		I programme	II design	III elaboration	IV realisation	V operation
quality control aspect	0 general					
	1 organisation					
	2 communication					
	3 requirements					
	4 means					
	5 purchase					
	6 time					
	7 finance					
	8 documentation					
	9 experience					

Process phases:

I Programme phase: In the programme phase an inventory takes place of requirements, demands and expectations of the ventilation system. Also all limiting boundary conditions must be listed and formulated. For the preliminary selection of the concept and type of ventilation system the main consequences are visualised. At the end of the programme phase the principal, architect and (ventilation) consultant have enough information to make a first selection of the ventilation concept/system.

II Design phase: In the design phase the ventilation concept, as preliminary selected in the programme phase, is elaborated by the ventilation consultant. Communication with architect and constructor takes place to tune building technical and architectural boundary conditions with the ventilation concept and vice versa. There will feedback to the starting points of the programme phase. At the end of the design phase a final selection of the ventilation concept takes place.

III Elaboration phase: In the elaboration phase the ventilation concept will be elaborated to a system level and a component level. Specifications will be elaborated and materialisation takes place in this phase. This includes also detailed financial calculations.

IV Realisation phase: In the realisation phase the actual construction of the ventilation system takes place. This phase ends with the acceptance and hand-over of the installation. Note that during this phase, and in particularly during the acceptance, “commissioning” takes place according to the “English” definition (i.e.: testing of the installation of realisation to check if it meets the terms of reference).

V Operation phase: In this phase the actual operation of the building and ventilation system takes place after the acceptance and hand-over of the installation. In ASHRAE publication 1996-1 this phase is cold “post-acceptance phase”. In this phase commissioning is the continued adjustment optimisation and modification of the ventilation system, including maintenance to meet and to maintain the specified requirements.

Quality Control Aspects:

0 General: Description the general objective(s) of each phase including the starting points, boundary conditions and points of particular interest.

1 Organisation: Description and allocation of tasks and responsibilities.

2 Communication: Description and recording of the necessary information exchange between all parties involved in the process is reported including a description about the necessary consultations including which parties, when, the objective and deliverables of each consultation.

3 Requirements: Inventory of internal and external requirements including a base level of legal requirements like buildings regulations, standards and others as well as recommendations, according to (higher) quality level.

4 Means: Listing of all necessary calculation methods, execution protocols, assessment and evaluation tools including references to standards (like calculation, determination and measurement methods) measurement instruments and literature.

5 Purchase: Description of necessary external expertise that has to be purchased.
6 Time: Guarding of the object planning as well as process planning.
7 Finance: Controlling and guarding of the object costs (i.e. ventilation installation) as well as the process costs (co-ordination, consulting, commissioning).
8 Documentation: Reporting of the input and output of all sequencing phases.
9 Experience: Evaluation of the process at the end of the phases

From the main cells in the matrix the will be references to other cells. In these cells is stated which subjects and partial subjects are addressed. In separate specification sheets these (partial) subjects are further elaborated:

QC MATRIX					
aspect	project phase				
	I	II	III	IV	V
0					
1					
2					
3		II.3			
4					
5					
6					
7					
8					
9					

CELL CONTENTS > BIM		
subject	partial subject	specification sheet
II.3-1		
II.3-2		
II.3-3		

SPECIFICATION SHEET II.3-2	
characteristic	specification

Using the BIMplement Model Quality and BIM-Skills Matrix it is not necessary (and often not possible) to fill in all cells. But every information that is available can be "recorded and stored" in logical way in a cell, elaborated in specification sheets and linked to BIM as the digital information carrier. Often this information is spread over two or more phases, consequently, over several specification sheets, corresponding with the distinguished phases and/or quality control aspects. It is important to analyse exactly in which phase and for what quality control aspect the information is necessary. Therefor it is important to know the meaning of each different quality control aspect. It is not possible and necessary to address all the quality control aspects. The chapters 5, and specially 6, 7 and 9 are much more related to specific projects. On the other hand it is possible to write general guidelines for quality control of ventilation systems within this BIMplement Model Quality and BIM-Skills Matrix structure without addressing these aspects.
BIMplement Model Quality and BIM-Skills Matrix is not only for consultants and installers. All partners in the building process have to deal with the BIMplement Model Quality and BIM-Skills Matrix and will have to confirm to it. Also the principle must be aware of the fact that his responsibility reaches further then only the financial aspects. He has an important role during the program phase to formulate functional specifications, that can be “translated” by his consultants in a technical design and specifications.
The BIMplement Model Quality and BIM-Skills Matrix structure provides a perfect basis for the implementation of commissioning within a (production) process. Within the matrix cells can be identified which should be addressed for commissioning. Specification sheets can be further elaborated. As a commissioning document on ventilation has a general character (i.e. not related to a particular project) not all cells can be filled in. More over all descriptions and specification sheets will give in many cases guidance how to fill in specifications related to a “real” project (this will be the case for organisation, communication, purchase, time, finance and experience). On the other hand, aspects as requirements, means and realisation can be elaborated in detail.

In general, following the BIMplement Model Quality and BIM-Skills Matrix cells can be filled regarding Quality Control and commissioning:

		project phase				
		I programme	II design	III elaboration	IV realisation	V operation
quality control aspect	0 general	I.0	II.0	II.0	IV.0	V.0
	1 organisation	I.1			IV.1	V.1
	2 communication	I.2			IV.2	
	3 requirements	I.3	II.3	III.3	IV.3	
	4 means	I.4	II.4	III.4	IV.4	V.5
	5 purchase				IV.5	
	6 time				IV.6	V.6
	7 finances			III.7	IV.7	V.7
	8 documentation				IV.8	V.8
	9 experience				IV.9	

Explanation:

I Program phase:

In 0 quality control must be mentioned as one of the boundary conditions in a project. This means that in the programme phase provisions must described in the ToR to execute all necessary activities for quality control (like BEMS, measuring points, balancing provisions, provisions for scheduled maintenance etc. etc.). In 1 can be stated who will be responsible for organising quality control (as described in 0) in the programme phase and in following phases and which other parties should be involved. In 2 can be described during which phases which parties should discuss quality control, what kind of meeting(s) are necessary as well as the deliverables of the meetings.
Very important is 3, in a direct way as well as in an indirect way. Indirect means that proper specifications and the understanding that a principal knows what he asks and what he gets (i.e. that the specifications meets his expectations) is the beginning of good quality control. Of course all necessary provisions for quality control (mostly needed in phase IV and V) must be specified already in phase I. Of special concern is specification of components and provisions that allows maintenance and cleaning.

II Design phase:

In the design phase all necessary provisions for quality control must be take into account in the final design and specifications.

III Elaboration:

In the elaboration phase final selection of provisions for quality control are selected. This means that component specifications must be given under 3 and selection criteria and methods for components must be given under 4. Purchase costs must be reported and guarded under 7.
Special concern is that for the final selection of components special requirements must be given to allow maintenance and cleaning. For example, if a ventilation concept contains metal ducts special requirements must be given for duct joints to avoid clogging and to allow cleaning (no screws!). Ventilation provisions in the facade must be selected such that cleaning is possible without the risk of destroying the controls and mechanisms or without the change to disturb adjustments..

IV Realisation:

In this phase actual quality control takes place. This means that in 1 the organisation of the quality control must be arranged (i.e. definition of responsibilities, who is doing what, quality control authority/organisation, installers, etc.). If specialist and external expertise must be hired in it must be reported under 5. Under 2 is arranged if meetings to arrange and discuss quality control and quality control results are necessary.
Directives and guideline values are reported in 3. Tools, instruments, checklist procedures, measurement methods etc. etc. are listed in 4. Guarding of planning and costs are described in 6 and 7. In 8 is precisely described how the quality control results must be reported and documented; (note; in 2 the authorisation and approval of these reports is arranged).

V Operation:

In the operation phase the continuous quality control process is arranged. Although the organisation and management structure that was operational during a building process is not available anymore in the operational phase the organisation of the continuous quality control can be described. It clearly will be another organisation and management structure then reported under I – IV. The tools and instruments as described under 4 will be partly the same as described in phase IV.
Special attention in phase V is needed for maintenance. This also includes schedules for maintenance, to be reported in 6, and costs (i.e. cost reservations), to be reported in 7. As in phase IV precisely described quality control results must be reported in 8.
Note that this description only gives a preliminary idea how to arrange and organise quality control in a logical way in the sequential phases of a production process. This structure can be elaborated if necessary. It can also be used to fill in

specification sheets on particular places where they are needed. In practice this can often follow from quality control aspect “9 – Experiences”.

1.9 Use on experimental sites

The BIMplement matrix will be used (in a simplified way) on the experimental sites (work package 4). The aim is to determine the components and/or aspects which are due to quality control and in which phase in the project. Also, it can be used to determine the professions/trades and skills that are needed and, linked to that, which competences the involved craftsmen should have (D3.1). In addition, trainings available on a national to achieve the necessary levels of competences can be linked (D3.2).

For example, in an experimental site a Mechanical Ventilation with Heat Recovery (MVHR) system is selected to be applied in dwellings. Then, for designing, selecting and installing a MVHR system in a dwelling, in the design phase a professional designer will be involved who should have knowledge of all the principles of MVHR, the (legal) requirements conform the building regulations, but also about the required level of airtightness of the dwelling. The designer should also be able to communicate with the architect, in order to optimize dwelling design in relation to the necessary duct work (i.e. in the matrix it can be indicated (under 2. Communication) that a meeting/consultation between the designer and architect should take place, including the expected outcomes. The output of the design phase is an actual design of the system (which can reported under 8. Documentation). This out put must be understandable for the purchaser (in the elaboration phase- III) to order right components and craftsmen (in the realisation or execution phase - IV) who have to do the actual installing work.
Under 3. Requirements the actual requirements of the MVHR system can be listed (i.e. required air flows, maximum energy use, control possibilities, maximum sound levels). These specifications are the basis for the handover in the realization phase (IV). Under IV.4 means the methods of measurements and verification can be described. For exampling, a description of the measurement procedures and equipment for measuring air flows as well as the way of reporting (in IV.8). In the next layer, the competences and vocational training can be listed to be able to perform the measurements.

2. Use of BIM in BIMplement

BIM can be a carrier for better project design and implementation work, only if each stakeholder, cross-level and cross-trade, know what he can/should do within a BIM model, and what does the other partners expect in terms of BIM model content. The whole stakeholders chains goes from client and project manager team, to building companies managers and down to on-site blue collar workers. It also means that specific BIM skills have to be developed for all of them in order for them to do both the quality control as the BIM job that is expected.
In following scheme the use of BIM in BIMplement for the different phases in the process and the the different professionals and craftsmen involved is shown:

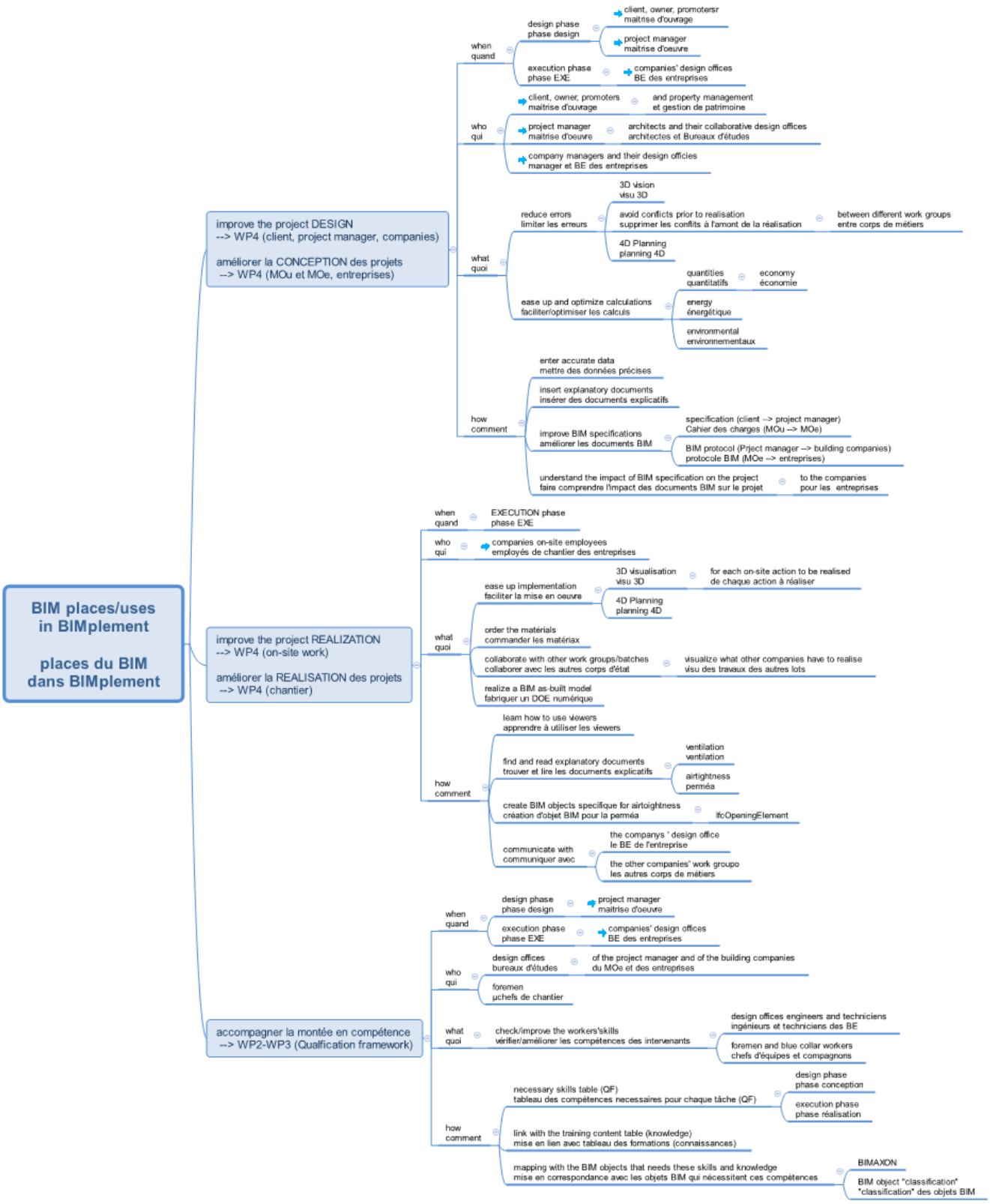


Figure 1. The use of BIM in BIMplement for the different phases in the process and the the different professionals and craftsmen

3. Quality control procedures in ‘real life’ environment

In the following chapters each involved organization **gave an overview of the quality control programs and procedures used in their countries, enterprises or that will be used for the identified experimental site.** Based on this quality control mapping (inventories), the actions will be further determined together with the experimental site identification (e.g.: number of ventilation units to be checked at the site).

It is highly recommended to work in close cooperation with the organisations related to the experimental sites. This to ensure that the selected quality control procedures are fit for purpose and use.

3.1 Quality control procedures in France

3.1.1 Quality control procedures in the area of ventilation

Existing quality control standards and protocols:

The European Standard EN 14134 specifies, checks and test methods in order to verify the fitness for purpose of installed ventilation systems in dwellings. It has just been revisited and the final document will incorporate in a good part the (following) results of PROMEVENT. Publication should occur beginning of 2019. French application texts should be published in the same time. Bellow the current PROMEVENT publications:

PROMEVENT référentiel de contrôle visuel:
https://www.rt-batiment.fr/fileadmin/documents/RT2005/labels_HPE/specificites_BBC/PJ3/Informations-et_doc_ressources/PROMEVENT/Referentiel_controle_visuel_ventilation.pdf

PROMEVENT Ventilation des bâtiments - Essai de performances et contrôles d'installation des systèmes de ventilation résidentiels, Amélioration des protocoles de mesure des systèmes de ventilation en résidentiel
http://www.promevent.fr/protocole/Protocole%20PROMEVENT_version%20oct%202016.pdf

PROMEVENTguide d'accompagnement du protocole Promevent, apporte, pour chacune des étapes du protocole, des illustrations et des méthodologies adaptées aux contraintes rencontrées sur le terrain
http://www.promevent.fr/guide/Guide_PROMEVENT.pdf

PROMEVENT Liste des points de vérification
http://www.promevent.fr/guide/Protocle_Promevent_Liste%20points_verification.xlsx

Means of quality control:

- Performance thermique des bâtiments - Guide d'application de la norme NF EN 13829:2001, NF DTU 68.3 P1-1-1 ventilation : design, calculation and implementation of mechanical ventilation systems.
- Partie 1-1-1 : Règles générales de calcul, dimensionnement et mise en œuvre – Cahier des clauses techniques types, NF DTU 68.3 P1-1-2
- Partie 1-1-2 : Ventilation mécanique contrôlée autoréglable simple flux -Règles de calcul, dimensionnement et mise en œuvre – Cahier des clauses techniques types prNF DTU 68.3 P1-1-4
- Partie 1-1-4 : Ventilation mécanique contrôlée autoréglable double flux - Règles de calcul, dimensionnement et mise en œuvre EN 16798-17
https://www.boutique.afnor.org/norme/nf-dtu-683-p1-1-2-a1/travaux-de-batiment-installations-de-ventilation-mecanique-partie-1-1-2-ventilation-mecanique-controlee-autoreglable-simpl/article/901480/fa191461
- Performance énergétique des bâtiments — Partie 17 : Ventilation des bâtiments - Module M4-11, M5-11, M6-11, M7-11 - Lignes directrices pour l'inspection des systèmes de ventilation et de conditionnement d'air, NF EN 14134

3.1.2. Quality control procedures

Existing quality control standards and protocols:

a) Building air-tightness:

- à partir du 1er septembre 2016, toutes les mesures de perméabilité à l'air de l'enveloppe des bâtiments devront être réalisées conformément à la NF EN ISO 9972, et à son guide d'application FD P50-784 associé.
https://www.rt-batiment.fr/batiments-neufs/etancheite-a-lair/information-et-documents-ressources.html
- norme NF EN ISO 9972
https://www.boutique.afnor.org/norme/nf-en-iso-9972/performance-thermique-des-batiments-determination-de-la-permeabilite-a-l-air-des-batiments-methode-de-pressurisation-par-ven/article/812722/fa167703
- FD P50-784 Juillet 2016, guide d'application de la norme NF EN ISO 9972

Performance thermique des bâtiments - Guide d'application de la norme NF EN ISO 9972, utilisé en association de la norme NF EN ISO 9972, s'applique uniquement à la mesure de la perméabilité à l'air des ouvrages de bâtiments ou de parties de bâtiments neufs ou existants.
https://www.boutique.afnor.org/norme/fd-p50-784/performance-thermique-des-batiments-guide-d-application-de-la-norme-nf-en-iso-9972/article/869006/fa063372

b) Ventilation network airtightness

nouvelles règles d'étalonnage de leurs matériels inscrites en **annexe B du FD P50-784**
https://www.boutique.afnor.org/norme/fd-p50-784/performance-thermique-des-batiments-guide-d-application-de-la-norme-nf-en-iso-9972/article/869006/fa063372
Means of quality control: Most of them are included in the procedures

3.2 Quality control procedures from The Netherlands

3.2.1 Quality control procedures in the area of ventilation

In general, requirements for ventilation are given in 'Het Bouwbesluit' (The Dutch Building Decree):
https://rijksoverheid.bouwbesluit.com/Inhoud/docs/wet/bb2012_nvt/artikelsgewijs/hfd3/afd3-6
Typical for the Dutch Building Decree is that all requirements are stated as so called 'functional requirements' linked with 'performance requirements'' i.e., no 'recipes' or required solutions are given.
The functional ventilation requirement for a structure to be built, has such a provision for air exchange that the development of a health-impairing quality of the indoor air is sufficiently limited. A table is given in the Building Decree, indicating regulations for each functional use that applies to that functional use. By complying with these regulations, the functional requirements are met.
The Building Decree references are made to NEN standards where the actual calculation and/or measurement methods are described.
Finally, in the Netherlands there is a system of supporting Assessment Guidelines 'Beoordelingsrichtijnen'. Assessment guidelines describe the way in which certification bodies assess whether an organization meets the technical requirements for obtaining or maintaining a certificate. A frequently used abbreviation for the word assessment guideline is BRL. The BRL describes which technical and organizational requirements an organization / product must meet in order to qualify for a certificate. These descriptions are elaborated in protocol. The BRL is by this way an instrument to support the Quality Control. For ventilation following BRL's are applicable:

Existing quality control standards and protocols:

- BRL 8010 – Ventilation performance inspection (source:https://kennisbank.isso.nl/docs/brl/8010/2012)
- BRL 6000-10 - Ontwerpen en installeren van ventilatievoorzieningen van woningen, basisscholen en kinderopvang (01-01-2017)

Furthermore is applicable:

- Erkenningsregeling Ventilatievoorzieningen in woningen en woongebouwen – Eisen voor bedrijfserkenning klasse 1 op het gebied van Ventilatievoorzieningen voor woningen en woongebouwen – Stichting Kwaliteit voor Installaties Nederland (01-07-2018)

Means of quality control:

- Duct Tester – used to detect leakage in air duct systems (source: https://retrotec.com/)

3.2.2 Quality control procedures in the area of air-tightness

Also for air tightness requirements are given in the Dutch Building Decree:
https://rijksoverheid.bouwbesluit.com/Inhoud/docs/wet/bb2003/hfd5/afd5-2
Qualitative requirements are given in NEN 2687:1989 nl - Luchtdoorlatendheid van woningen – Eisen
Furthermore is applicable for measurements:

Existing quality control standards and protocols:

- ASTM E1827 – 11(2017) en – Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower. (source: https://www.nen.nl)

Means of quality control:

- Blower Door System – for the inspection of the airtightness of spaces (sources: https://retrotec.com/, https://www.blowerdoor.de)

Specific requirements are given for the airtightness of floors between a dwelling and a crawl space. There is a specific measurement procedure given in NEN 2690:1991+A2:2008 Luchtdoorlatendheid van gebouwen - Meetmethode voor de specifieke luchtvolumestroom tussen kruipruimte en woning

3.3 Quality control procedures from Poland

3.3.1 Quality control procedures in the area of ventilation

Existing quality control standards and protocols:

- PN-EN 12599:2013-04

Ventilation for buildings – Test procedures and measurement methods to hand over air conditioning and ventilation systems

- PN-EN 14134:2008

Ventilation for buildings. Performance testing and installation checks of residential ventilation systems

- PN-EN ISO 12569:2017-12

Thermal performance of buildings and materials – Determination of specific airflow rate in buildings – Tracer gas dilution method

Means of quality control:

Ventilation for buildings contains airflow measurement method, speed of air measurement method, air humidity measurement method, noise level measurement, measurement of power consumption and others. The standard is used for the installation of ventilation and air conditioning designed to maintain comfort conditions in buildings.

Ventilation for buildings – performance testing and installation checks of residential ventilation systems - it can be used both for receiving new installations and for testing properties of existing installations. The standard allows testing the flow rate of supply and exhaust air in a mechanical and natural ways.

Thermal performance of buildings and materials contains tracer gas dilution method.

The measurement method is important in spaces where the combined conditions for uniform tracer gas concentration, measurement of gas discharge concentration, effective mixing zone and / or ventilation fluidity are satisfactory. Three methods of measuring using tracer gas are given: concentration decay method, string method dosing and the method of constant concentration.

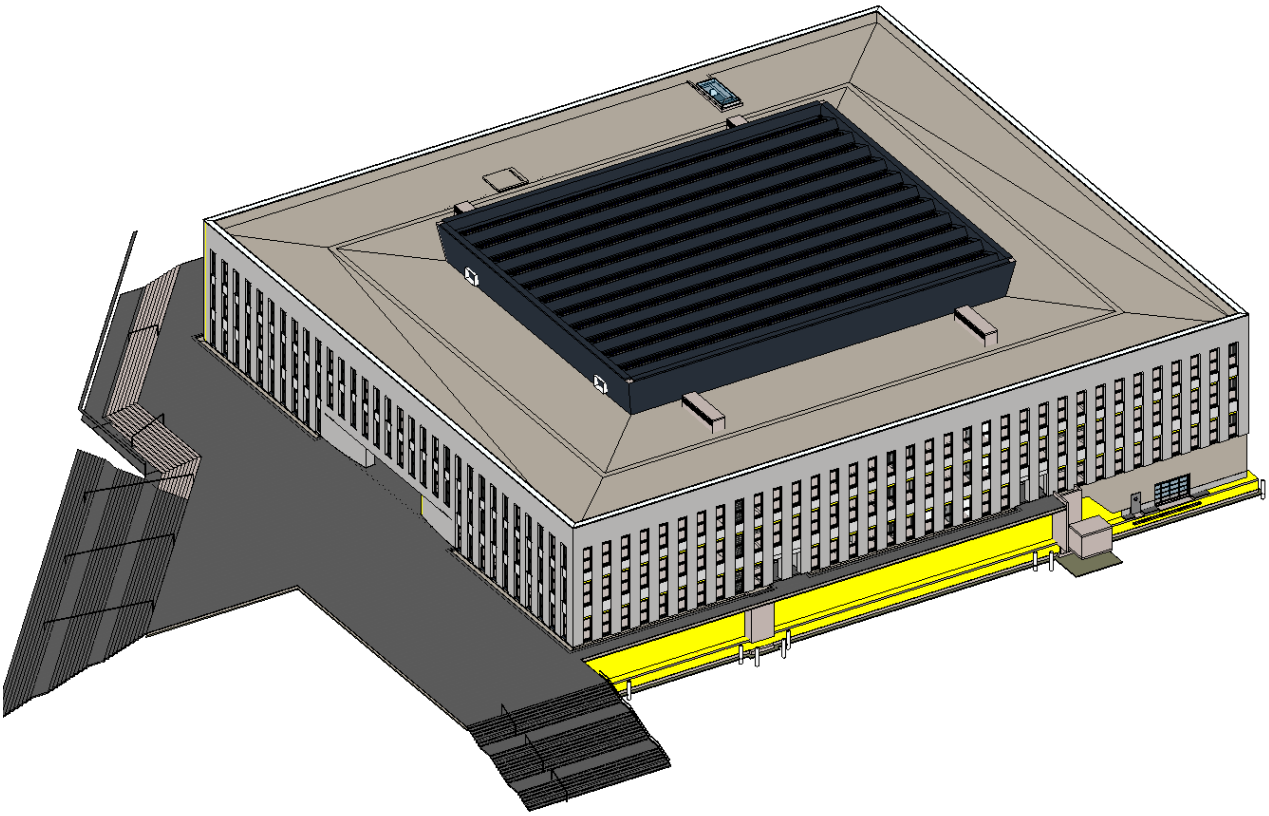


Figure 2: Construction model of Poznan University of Technology.

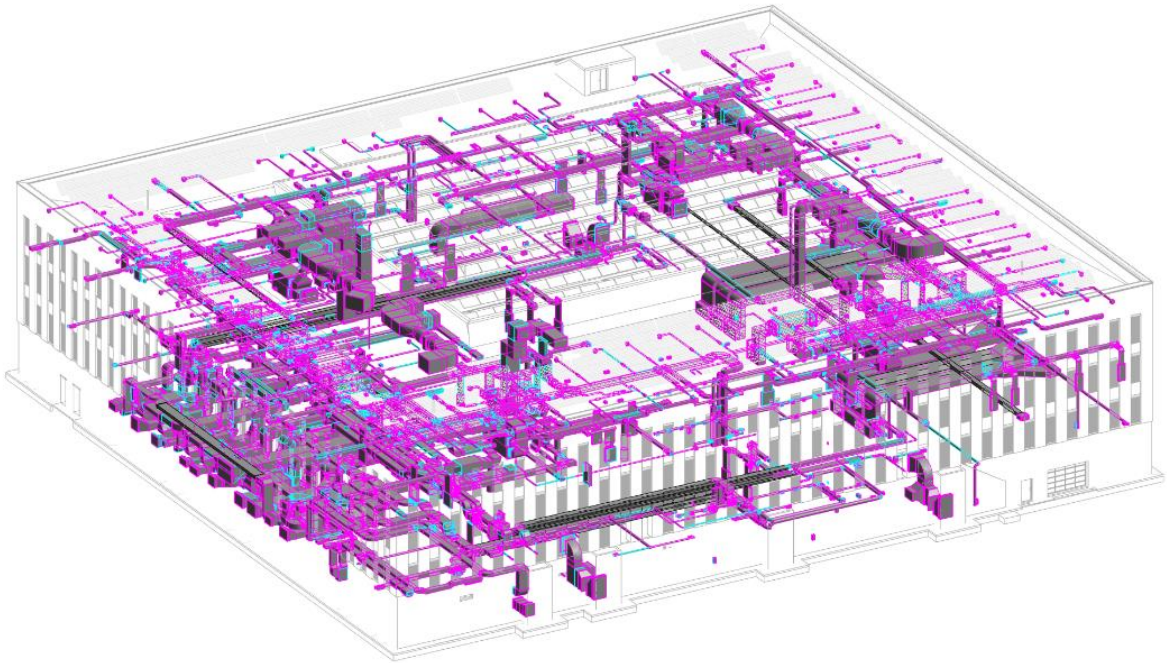


Figure 3: HVAC Model of Poznan University of Technology.

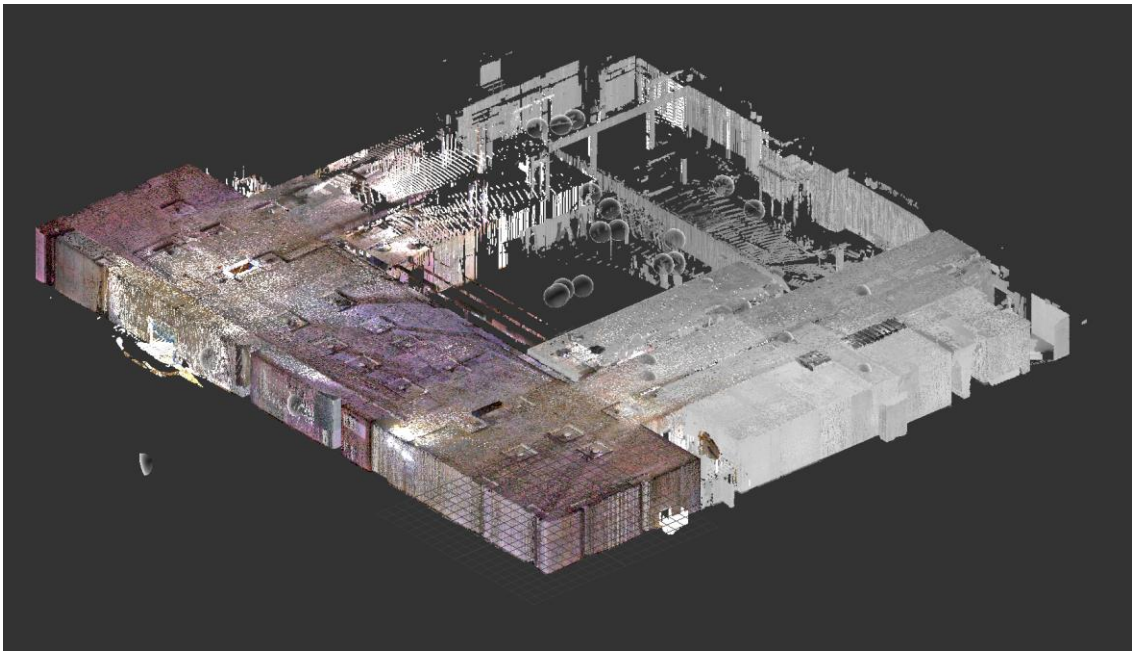


Figure 4: Point cloud of Poznan University of Technology.

Below is shown example of sanitary checklist (Example of internal acceptance report for central heating.

This is internal acceptance report for central heating where are accepted e.g.: insulation, air-tightness, assembly of fittings and devices, regulation of instalation, documentation based on e.g.: WTWiO Note nr.6 COBRTI INSTAL, PN-B-02421:2000, PN-B-02151-3:1999.

Table 1 presents an example of internal acceptance report for central heating.

WEWNĘTRZNY PROTOKÓŁ ODBIORU ROBÓT Nr ……

Roboty: m-ż instalacji c.o.	Przedmiot odbioru:	Kierownik budowy:	
Budowa:	.....	Osoba dokonująca odbioru:	
Lokalizacja:			

Lp	Sprawdzono	Rezultat odbioru (bez uwag / uwagi)	Aprobata wstępna Data i podpis	Odbiór poprawek	Aprobata Data i podpis
1	Zgodność z dokumentacją wykonawczą i zasadami wiedzy technicznej				
2	Dokumentacja powykonawcza				
3	Dopuszczenie materiałów do obrotu i powszechnego lub jednostkowego stosowania w budownictwie				
4	Oględziny zewnętrzne instalacji				
5	Płukanie instalacji				
6	Badanie szczelności instalacji - próba ciśnieniowa p_o=..... bar				
7	Wykonanie zabezpieczeń ppoż.				
8	Wykonanie zabezpieczeń antykorozyjnych pow. zewn.				
9	Wykonanie izolacji instalacji				
10	Montaż armatury regulacyjnej				
11	Montaż armatury i urządzeń				
12	Badania odbiorcze zabezpieczenia instalacji ogrzewczej przed przekroczeniem granicznych wartości ciśnienia i temperatury				
13	Badania odbiorcze poprawności działania i szczelności na gorąco				
14	Regulacja instalacji				
15					
16					

Tabela nr 1 Badania i próby poszczególnych parametrów instalacji [korygowane w zależności od specyfiki robót]

Określenie przedmiotu pomiaru	Wymagania	Dokument odniesienia
Badanie szczelności instalacji c.o.	wg odpowiedniej normy	WTWiO Zeszyt nr.6 COBRTI INSTAL
Badanie izolacji cieplnej	wg odpowiedniej normy	PN-B-02421:2000
Badanie poziomu natężenia hałasu	wg odpowiedniej normy	PN-B-02151-3:1999

Zaakceptowano przez Mostostal Warszawa S.A.

Podpis:	Data:
Imię i nazwisko:	

Normy związane: PN-EN 14336:2005(U), PN-B-02421:2000, PN-B-02151-3:1999

IB.2-6 w.3 Druk nr 2a

Michał Wasiak:
Uwaga: Kierownik budowy każdorazowo przed dokonaniem odbioru robót, zobowiązany jest do weryfikacji wymagań określonych w umowie przez zleceniodawcę/i lub w dokumentacji technicznej. W przypadku kiedy wymagania te nie są określone, należy opierać się na polskich normach przywołanych w drukach wcześniej weryfikując aktualność stosownych norm.

Table 1: Example of internal acceptance report for central heating.

The project describe such parameters as:

Lp.	Mark	Value	Unit	Parameter
1	n_{50}	0,3	h^{-1}	air-tightness
2	$\eta_{oc,n,H}$	0,75	-	efficiency of heat recovery
3	A_f	14233,0	m^2	useable ares

3.3.2 Quality control procedures in the area of air-tightness

Existing quality control standards and protocols:

- PN-EN ISO 9972:2015-10

Thermal performance of buildings - Determination of air permeability of buildings – Fan pressurization method

- PN-EN 13187:2001

Thermal performance of buildings – Qualitative detection of thermal irregularities in building envelopes – Infrared method

Means of quality control:

Thermal performance of buildings – fan pressurization method specifies the use of mechanically generated overpressure or underpressure in a building or part of it. The measurement of the resulting values of air streams in the range of static internal / external pressure differences is described. Helps to determine building air-tightness, quantify air leakages and pressure differences.

Thermal performance of buildings – infrared method – this standard gives two variety of thermography: examination with an IR camera and simplified examination with IR camera. The standard doesn't apply the quantification of thermal insulation and air tightness of a structure.

In respect to the Polish expermintal site, the assembly process of the HVAC installation is now in the initial phase. The model of all installations in engine room of the building will be presented using augmented reality.

3.4 Quality control procedures from Spain

3.4.1 Quality control procedures in the area of ventilation

Existing quality control standards and protocols: The standards and protocols that are commonly followed for quality control and quality assurance are listed below.

- UNE 12599:2014 Ventilación de edificios. Procedimientos de ensayo y métodos de medición para la recepción de los sistemas de ventilación y de climatización instalados. *(en: Ventilation for buildings – Test procedures and measurement methods to hand over air conditioning and ventilation systems).*
- UNE-EN 14134:2004 Ventilación de edificios. Ensayos de prestaciones y controles de instalaciones de sistemas de ventilación en viviendas. *(en: Ventilation for buildings. Performance testing and installation checks of residential ventilation systems).*
  This standard is still in force but will be soon repealed by PNE-prEN 14134 which is process.
- UNE-EN ISO 12569:2017 Comportamiento térmico de los edificios y de los materiales. Determinación del caudal de aire específico en edificios. Método de dilución de gas trazador (ISO 12569:2017) (Ratificada por la Asociación Española de Normalización en octubre de 2017.). *(en: Thermal performance of buildings and materials - Determination of specific airflow rate in buildings - Tracer gas dilution method (ISO 12569:2017) (Endorsed by Asociación Española de Normalización in October of 2017.)*

Means of quality control: Below are described methods, techniques, tools, instruments used to check and demonstrate compliance.

- Tracer gas dilution method. This method aims to check the ventilation flows in each of the rooms, make the overall balance, balance intake-extraction and quantify the infiltration flows. The main results of this method are air renovation rate (h^{-1}); global balance of air renovation in the dwelling: ventilation + infiltrations; verification of the ventilation system compared with the project; detection of zones where air is stagnant; measurement of “age of the air”. This method is applied according to the procedure defined in UNE-EN ISO 12569:2017 (see previous section).
- Checklist to control whose main goal is to ckeck that the documentation included in the Execution Project is complete and enough to be able to install the ventilation systems ensuring the quality.

P4	CONTROL TÉRMICO	PLANIFICACIÓN	SISTEMAS DE VENTILACIÓN
OBRA			

El proyectista o el redactor del Plan de Control de Calidad debe comprobar que el proyecto de ejecución incluye o especifica las siguientes características de los sistemas de ventilación:

		SI	NO	Observaciones
1.	Memoria y planos de los sistemas de ventilación			
2.	Marca y modelo de los equipos de VMC			
3.	Dimensiones y colocación de los equipos			
4.	Caudales de renovación de aire en diseño [m^3/h]			
5.	Superficie/estancias a las que da servicio cada equipo VMC			
6.	Eficiencia de los recuperadores de calor [%] Norma UNE-EN 13141-7:2011			
7.	Consumo eléctrico ó SFP [W] Norma UNE-EN 13141-7:2011			
8.	Nivel de potencia acústica [dB] Norma UNE-EN ISO 5135:1999			
9.	Clases de filtros para admisión y extracción			
10.	Descripción de los conductos de ventilación			
11.	Descripción de las aberturas de ventilación (admisión, de paso y de extracción)			
12.	Previsión de algún tipo de regulación de los caudales de ventilación			
13.	Previsión de medidas y/o soluciones de estanqueidad en la red de ventilación			

Observaciones/ Medidas Correctoras:	Dirección Facultativa/ Constructor:

Source: Guía básica para el control térmico en la edificación. 2016. Gobierno Vasco. (en: Basic guidelines on thermal control in buildings)

- Checklist for materials' reception control to check that all the received components of the ventilation system have the same characteristics than those defined in the Execution Project.

R4	CONTROL TÉRMICO	RECEPCIÓN	PRODUCTOS Y EQUIPOS DE VENTILACIÓN

OBRA	

La Dirección Facultativa debe realizar las siguientes actuaciones durante la recepción de equipos del sistema de ventilación en la obra:

PRODUCTO O EQUIPO DEL SISTEMA DE VENTILACIÓN					
1. El producto llega a obra con el embalaje original, debidamente etiquetado y en perfectas condiciones	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
2. El embalaje contiene la etiqueta identificativa con las características esenciales del producto	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
3. Presencia de documento de calidad					
3.1. Documentos de origen, hoja de suministro y etiquetado.	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
3.2. Certificado de Garantía del fabricante, firmada por persona física	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
3.3. Etiquetado del marcado CE	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
3.4. Declaración CE de conformidad firmada por el fabricante	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
3.5. Marcas de conformidad a Norma de Producto	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
3.6. Certificado de conformidad a requisitos reglamentarios (sin marcado CE)	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
3.7. Documento de Idoneidad Técnica DIT	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
3.8. Documento de adecuación al uso DAU	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
3.9. Certificado de ensayos realizados por un laboratorio	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
4. El producto es el especificado en proyecto	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
5. Las características del producto cumplen con lo especificado en la memoria del proyecto					
5.1. Dimensiones del equipo VMC	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
5.2. Eficiencia del recuperador de calor según la norma EN 13141-7 (si procede)	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
5.3. Consumo eléctrico o SFP	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
5.4. Caudal de renovación de aire de diseño (m3/h)	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
5.5. Clases de filtros en admisión y extracción	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
5.6. Sistema de regulación de caudal de ventilación	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
6. Se han seguido las recomendaciones del fabricante en el almacenamiento o acopio del producto	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐	Si☐ No☐
Observaciones					

Observaciones/ Medidas Correctoras:	Dirección Facultativa/ Constructor:

Source: Guía básica para el control térmico en la edificación. 2016. Gobierno Vasco. (en: Basic guidelines on thermal control in buildings)

- Checklist to check the proper installation of the ventilation system.

E4	CONTROL TÉRMICO	EJECUCIÓN DE LA OBRA	SISTEMAS DE VENTILACIÓN

OBRA	

La Dirección Facultativa debe comprobar que durante la instalación del sistema de ventilación se realizan las siguientes actuaciones:

	SI	NO	Observaciones
IDENTIFICACIÓN DEL SISTEMA DE VENTILACIÓN			
1. Aberturas de ventilación			
1.1. Identificar las aberturas de ventilación			
1.2. Comprobar el montaje de aberturas de ventilación según proyecto			
1.3. Comprobar la regulación de las aberturas de ventilación			
1.4. Comprobar las dimensiones de las aberturas de paso integradas en puertas y particiones.			
2. Conductos de ventilación			
2.1. Identificar los conductos de ventilación			
2.2. Comprobar montaje de conductos según proyecto			
2.3. Comprobar montaje de válvulas (antiretorno, anti-incendio, etc.)			
3. Unidades de ventilación			
3.1. Identificar las unidades de ventilación			
3.2. Comprobar montaje de las unidades de ventilación según proyecto			
3.3. Comprobar los filtros instalados según proyecto			
4. Regulación de la ventilación:			
4.1. Comprobar el montaje de sondas de control (CO_2, humedad, presencia, etc.)			
5. Comprobar el estado de los filtros antes en el fin de obra (sustituirlos si es necesario)			
6. Previsión de ensayo de puerta ventilador, Norma UNE-EN 13829			
7. Documentación complementaria adjunta (fotografías, planos, etc) con identificación y fecha			

Observaciones/ Medidas Correctoras:	Dirección Facultativa/ Constructor:

Source: Guía básica para el control térmico en la edificación. 2016. Gobierno Vasco. (en: Basic guidelines on thermal control in buildings)

3.4.2 Quality control procedures in the area of air-tightness

Existing quality control standards and protocols: Below are described standards and protocols that are commonly followed for quality control and quality assurance.

- UNE-EN 13829:2002 / UNE-EN 13829 ERRATUM:2010 Aislamiento térmico. Determinación de la estanquidad al aire en edificios. Método de presurización por medio de ventilador. (ISO 9972:1996, modificada). *(en: Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method. (ISO 9972:1996, modified).*
- PNE-EN ISO 9972 Prestaciones térmicas de los edificios. Determinación de la permeabilidad al aire de los edificios. Método de presurización por medio de ventilador. (ISO 9972:2015). *(en: Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method (ISO 9972:2015).*
  This standard is in process. Once it enters into fource, UNE-EN13829:2002 and UNE-EN 13829:2002 ERRATUM 2010 will be repealed.
- Complementary: UNE-EN 13187:1998 Prestaciones térmicas de edificios. Detección cualitativa de irregularidades en cerramientos de edificios. Método de infrarrojos. (ISO 6781:1983 Modificada). (Ratificada por Aenor en Noviembre del 2000). *(en: Thermal performance of buildings - Qualitative detection of thermal irregularities in building envelopes - Infrared method (ISO 6781:1983 modified).*

Means of quality control: The most common methods, techniques, tools, instruments used to check and demonstrate compliance, inspection techniques on the site are presented below:

- Blower Door Test helps to determine building air-tightness, quantify air leakages and pressure differences. This method is applied according to the procedure defined in UNE-EN 13829:2002 and UNE-EN 13829:2002 ERRATUM 2010 (see previous section).

Figure 5 Blower door

- Complementary tecniques such as infrared thermography are also used to locate, identify and classify air leakage points in the building. Thermal images are used to easily identify these leakeage points. This technique is applied according to the procedure defined in UNE-EN 13187:1998 (see previous section).

3.5 Quality control procedures from Lithuania

3.5.1 Quality control procedures in the area of ventilation

Construction rules are commonly followed for quality control and quality assurance. Portal www.statybostaisykles.lt serves a system of minimum requirements for construction technology and quality requirements, especially for those construction actors who are directly involved in the implementation of construction projects. In addition to creating a good construction practice on the safety of workers it provides the latest construction technology information. More information can be found http://www.statybostaisykles.lt. The chapter 2.5 presents Quality control part of Construction rules related to airtightness and ventilation topics as common for Lithuania.

Quality control part of Construction rules

Mechanical ventilation systems installation work. Variable air flow ventilation systems installation

Table below presents the main control objects for the installation of variable air flow ventilation systems.

Quality requirements, control methods and methods

Abbreviations: SPVP - maintenance of the construction project; SSTP - technical maintenance of the construction of the building; SSV - the head of the construction of the building; RPC - the person authorized by the contractor responsible for work safety at the construction site; SK - Coordinator of Construction Safety and Health at Work; A - responsible; D - participant; I - Informed.

No	Control object	**Control phases**	**Control methods**	**Remarks**	Responsible / Participants
1.	Specification	- Verification of materials compliance declarations.	Verification of documents	Incompatibilities are not allowed	A: SSTP D: SPVP; SSV;
		- Checking if substances are accomponied with material safety data sheets	Verification of documents	Incompatibilities are not allowed	A: RĮA;
		- check the compliance of the system elements with the Project.	Project verification	Incompatibilities are not allowed	A: SPVP D: SSTP, SSV
2.	Register	checking / approval of the planned construction works and their quantities.	Project verification		A:SSV, SSTP D: SPVP I: Užsakovas
3.	Staff training	- Checking whether employees pay and know how to use work tools, personal protective equipment and are familiar with the information	Document checking, conversation	Incompatibilities are not allowed Esant būtinybei, tikrinami darbuotojo praktiniai gabumai	A: RĮA;

		provided in the Material Safety Data Sheets.			
4.	Work tools	- checking that the technical condition of the work equipment issued complies with the requirements for use of the documentation provided by the manufacturer..	Verification of documents, visual		A: RĮA;
		- Check that the electrical installation is installed in such a way that it does not endanger the safety and health of workers.	Visually		A: RĮA I: SK;
		- checking that the insulation of the cable, the handles, or the plugs is not damaged by the electrical tools and devices, are in good order, and that the mechanisms for switching on and off are in order	Visually		A: RĮA;
5.	Mounting of fasteners	- Checking if the fitting is carried out in accordance with the project instructions.	Project verification		A:SSV, SSTP D: SPVP I: Užsakovas
		- Checking if the fixing points are mechanically durable or have sufficiently thick elements.	Visually		A: RĮA;
6.	Duct mounting	- checking that there is no dust, debris, or dust on the ducts	Visually		A: RĮA;
		- Checking if the ducts are installed tightly, cracks are not seen, or the	Visually		A: RĮA;

		spacers are everywhere and tightened. -			
7.	Insulation installation	- Checking how the thermal insulation is adhering to the surface (i.e. avoiding cold bridges).	Visually	Push up to 5mm	A: SSTP; SSV
8.	VAV installation	- Checking that all appliances are connected according to the manufacturer's recommendations;	Visually		A: RĮA;
		- Checking if the pressure measuring hoses and other elements of the VAV are reliably connected.	Visually		A: RĮA;
*	REQUIREMENTS OF SPECIFIC MANUFACTURER SHALL BE MET				

3.5.2 Quality control procedures in the area of air-tightness

FACADE INSTALLATION WORKS. Installation of ventilated facades with mineral wool thermal insulation

1. Evaluation of the integrity of the substrate.
1.1. The tightness of the substrate must comply with the requirements of clause 10.3 of STR 2.05.01: 2005 "Thermal insulation of building partition walls" and must be guaranteed prior to installation of the System. The sealing of the base from the air flow is carried out inside the building.
1.2. Before starting the installation of the facade, it is necessary to check the design of the tightness fitting solutions. If the installation of the substrate in the project is foreseen on the outside, these works must be carried out before the facade insulation works. The installation of the sealing layer is not standardized in the installation of the facade system.
1.3. During the system and other installation of the building, the tightness of the building can not be reduced.
1.4. When installing additional engineering systems, fastening to the base or through the base, the building's tightness can not be reduced.

2. Assessment and acceptance of the quality of the substrate
2.1. The substrate surface roughness should not be greater than the thickness of the system provided by the manufacturer. In cases where the surface roughness is greater than the thickness of the system provided by the manufacturer, the surface of the substrate must be aligned.
2.2. The dirt, mortar residue, and other deflected parts that may interfere with the quality of the work of the System work steps are wiped / broken by appropriate means
2.3. If the enclosure wall is made of bricks or blocks that do not have a clam, then all vertical and horizontal seams must be completely filled with mortar. Can not rewind seams by checking them from inside or outside; .

2.4. If the enclosure wall is made up of bricks or blocks with connecting clips then all horizontal joints must be filled with glue or mortar. You can not wrap the seams by checking them out from the inside or outside.
2.5. Seams of monolithic septum walls must be completely filled with mixtures provided for in their installation conditions. You can not wrap the seams by checking them out from the inside or outside.

3. Estimation and acceptance of the work of window and door windows and doors and other facade fastenings
3.1. Prior to the installation of the system, it is necessary to evaluate the design of the window and door installation and sealing solutions. If the installation of the tightness in the project is foreseen in the outside of the Base, these works must be carried out before the installation of the facade system. For the nuts, the sealing process and the technological solution must be submitted to the DP. The installation of the window and substrate sealing layer is not standardized in the installation of the facade system.
3.2. Check and match the diffusion layer around windows and doors from outside installation solutions with window installers:
3.2.1. Before starting the installation of the facade, it is necessary to check the design of the solutions for the installation of the window diffusion layer on the outside. Solutions must be provided by the DP.
3.2.2. In all cases, for the selection of the diffusion layer, mounting technology and the final result, the window installer is responsible;
3.2.3. Window installers must be informed about the process of the installation of the facade, the order and the terms.
3.2.4. It is recommended that the installers of the windows coordinate the work schedule;
3.2.5. If the installation of a diffusion layer in the project is to be performed before the facade insulation works, the fact of installation of the diffusion layer must be recorded in the work execution journal. In this case, the Facade Installer must ensure that this layer is mechanically intact when installing the façade system;
3.2.6. If the installation of the window diffusion tape in the DP is provided after the installation of the frame, then before the installation of the cavities:
3.2.6.1. facade installers must inform window installers in writing about the fact of the preparation for the completion of window refinishing works;
3.2.6.2. the installers of the windows must install a diffusion layer according to a harmonized schedule;
3.2.6.3. Façade installer completes installation of the System;
3.2.7. Upon completion of the installation of the facade system, the installers of the windows must check and accept or mechanically damage the diffusion layer;

4. Addition of additional engineering systems installed on the base. (in the menu)
4.1. All works of engineering networks and equipment that are fastened to the building's foundation or through the foundation of the building must be completed before the installation of the System is completed, or in accordance with a separate project, works are carried out in parallel with the installation of the System;
4.2. At the base of the foundation, the fixing solutions for additional engineering systems, such as solar collectors, must be provided for in the work project.
4.3. In the project work, it is necessary to evaluate the heat loss of additional systems that are fastening or underlying, and to provide an additional insulation layer or to use other type of fastening elements in order not to reduce the thermal characteristics of the partition.

5. Selection and installation of additional mounting elements for the equipment.
5.1. All works of the Supplementary equipment attached to the building's base or through the foundation must be completed before the installation of the System is completed, or in accordance with a separate project, works are carried out in parallel with the installation of the System; Normally not included in the installation of facade systems.
5.2. Additional mounting of the equipment to the facade. Attachment of additional equipment to the façade can be carried out only on the basis of the specific installation of the equipment and mounting housings. Additional assemblies must be prepared for unplanned fitting of equipment.
5.3. If any equipment or additional elements are intended to be hung on the wall, they must be fitted with special holders during this stage of work, and the finishing elements, when assessed, are attached to the frame.
5.4. The equipment must be approved in accordance with the manufacturer's conditions and requirements.

5.5 When fixing additional equipment to the base, its tightness can not be reduced
5.6. Finishing elements can not have sharp corners that can be dangerous in the operation of the facade.
5.7. It is necessary to estimate the heat loss caused by additional elements.

FACADE INSTALLATION WORKS
Installation of external plaster composite thermal insulation systems

According to each section of the quality section there must be records in the construction work journal.

Quality requirements, control methods and methods

No	Control object	Checking method	
1.	Preparation for ISTS installation		
	Project	- Whether a technical, work or technical work project has been submitted; - Whether the submitted technology (execution) project (if required);	
	ISTS specification	- Verification of compliance with the manufacturer's or supplier's specific system declaration; - check the compliance of the composition of the system with the technical, work or technical work project.	
2.	Preparation of construction object		
	Staff training and coaching	- Checking whether employees are trained in safe and appropriate working methods, have appropriate knowledge and ability to work safely	have the necessary certificates, certificates, are familiar with the safety and health requirements at the construction site, safety and health solutions in the technology (execution) project
		- Checking whether employees pay and know how to use work tools, personal protective equipment and are familiar with the risks posed by the materials used.	
	Construction site	- Checking that the construction site is fenced at a height of at least 1.6 m high to prevent unauthorized entry of construction sites in the settlements and operating companies; - check that the electrical installation is installed in such a way that it does not endanger the safety and health of workers; - checking the house and hygiene facilities installed on the construction site; - checking whether materials are stored at the locations provided for in the project; - checking that the necessary measures are taken to remove building materials.	
	Scaffolding	- Scaffolding is checked according to the prepared scaffolding project;	Scaffolding project
		- Checking whether the scaffolds have been installed, a completed scaffold check sheet and a periodic scaffold check are submitted to the work manager;	Scaffold Inspection Sheets

		- Checking whether the scaffolding supports are mounted on a solid and compact foundation; - Checking whether the metal scaffolds are grounded; - Checking if enclosures are installed to protect workers from falling from a height; - Checking that the scaffolds are adequately covered by a safety net; - checking that the access to the scaffolding deck is adequate.		Visually
3.	Assessment and acceptance of the foundation and other related constructions			
	Preparation of the substrate	- Assessment and preparation of the substrate is checked (Table 1).		
T3.1	Strength of the base		≥ 0,08 MPa	Aperture force measuring device (eg COMTEST® OP1)
T3.2	Base deviations in the facade plane in horizontal and / or vertical directions		20 mm/m'	Roulette, theodolite
T3.3	Horizontal and vertical seams filled		~50 mm išilgai ~20 mm į gylį	Visually and in roulette
T3.4	Installation of waterproofing of foundations and other planes adjoining land		According to project	Visually
	Building tightness	- The design solutions for the installation of the tightness of the foundation are checked. If the installation of the underlying tightness in the project is foreseen in the outer part, the act of hiding the installation of this solution must be submitted.		Act of Hidden Works
	Acceptance of window and door installation	Prior to the installation of the system, it is necessary to evaluate the design of the installation of windows and doors and the installation of tightness and diffusion layers. DP provided solutions. Work has been done. Evaluated.		Act of Hidden Works
	Adoption of additional equipment fixing elements	DP provided solutions. Work has been done.		Act of Hidden Works
4.	Gluing of thermal insulation boards			

	Gluing of thermal insulation boards	- Lubrication of the adhesive mixture and pressure of the thermosetting panels by opening the randomly selected panels are checked; - The sealing of cracks and system adherence to other structures is checked; - Checking the thermal insulation boards, removing the adhesive mixture from the joints, filling the joints with cuttings or sealing foam; - Inspection of thermal insulation boards, bonding at the edges of facades and openings; - Gluing thermal insulation boards to thermodeforming seams is checked; - Installation of drainage slopes is checked.		
T4.1	Deviation of gluing of thermal insulation panels in the facade plane in horizontal and / or vertical directions		2 mm/m'	Roulette, theodolite
T4.2	Bonding of thermal insulation panels and overlap of reinforcing mesh bands		≥ 100 mm	Ruler, roulette
T4.3	Local deviations by measuring 2 m long ruler		4 mm	2 m long ruler, roulette
T4.4	Deviations of curvilinear surfaces from a horizontal or vertical		30 mm	the tail, roulette
T4.5	Separate slot opening deviations from horizontal or vertical		3 mm/m'	1 meter long ruler, spirit level, roulette
5.	Mechanical fastening with studs			
	Mechanical fastening with studs	- Checking the conformity of the studs and their amount in the 1 m² plane to the project; - Checking and fixing the studs, can be performed on a randomly selected sample extraction test.		
T5.	The force of extraction of strings		Projected kick force extraction force kN	extraction force measuring device (eg COMTEST® OP 1)
5.1	Reinforced layer installation			
	Reinforced layer installation	- additional reinforcement is checked at the edges of the holes (installation of angular profiles with a grid, diagonal grid sections, etc.); - Inspection of the laying of the reinforcing mesh, overlapping of the grid strips; - checking of the reinforcing mesh covering with putty; - the thickness of the reinforced layer is checked by incision of randomly taken places; - checking the compliance of the studs with the number of studs in the 1 m² plane through the grid, pinching and fixing the studs; - Inspection of the laying of the reinforced layer in the area of the roof profile.		
T5.2	The deflection of the reinforced layer in the facade plane in horizontal and / or vertical directions		decorative plaster size + 0.5 mm / m	roulette, roulette, theodolite

7.	Installation of final surface finishing layer			
	Installation of final surface finishing layer	- Protective (anti-corrosive) dyeing of metal parts fastening to the system; - priming of the reinforced layer is checked (if system is foreseen); - Checking hard-to-reach areas with decorative plaster; - checking the uniformity of the pattern and color of the decorative plaster layer.		
T7.1	The uniformity of decorative plaster pattern and color		according to the benchmark	benchmark
8.	Personal protective equipment			
	Personal protective equipment	- checking that the personal protective equipment selected and issued is in accordance with the nature of the work (prevention of emerging hazards), manufacturer's instructions and recommendations; - Checking whether employees use personal protective equipment.		Visually
9.	Collective protection measures			
	Bags, Occupational Safety and Health Signs	- Checking or installing enclosures alongside massive traffic paths of people, which must be at least 2 m, with a solid protective roof protecting against falling objects; - Inspection or installation of appropriate signs of occupational safety and health, in places where hazardous and / or harmful factors can occur / occur.		Visually
10.	Work tools			
	Electric tools, ladders and other tools	- Checking that the ladders are of sufficient length, without clearly visible defects, and that they are periodically inspected for their technical condition; - Checking whether the technical condition of the work equipment used is correct and whether the maintenance and use requirements laid down in the manufacturer's documentation for use are met; - Inspection of electrical tools and devices without damage to cable, handle insulation, regular plugs, activation and shut-off mechanisms.		Visually

FACADE INSTALLATION WORKS
Installation of glass aluminum facades

Assessment and acceptance of the quality of the substrate

- During the base preparation work from scaffolding extending from the structure is more than 300 mm. A scaffold lateral protection consisting of an armchair, an intermediate beam and a stump shall be provided with a distance.
- The surface of the walls must be smooth, clean, undamaged and durable.
- The dirt, mortar residue, and other deflected parts that may interfere with the quality of the work of the System work steps must be cleaned or damaged by appropriate means.

- In assessing the quality of the substrate, it is very important to evaluate the level of foundation in the place where the brackets will be deviation from the axis altitudes, because it is important that the bracket will fit the entire area.
- It is also important to know the layout of the fixture so that it is clear where the fixture is located so that it does not damage it. These questions need to be clarified and the solutions presented at the design stage.
- If the roofs to which the facade will be attached will be tensile ropes, exact rope layout and height will be required on the ceiling. These questions need to be clarified and the solutions presented at the design stage.
- Upgrading the old buildings, the requirements for the preparation of the foundation must be provided in the design documentation.
- A geodetic fill photo of bearing structures must be provided during the design of the facade work or a constructive final revision has to be obtained, according to which the construction will be carried out, and the draft must provide for tolerances;
- Until the beginning of the design, maximum tolerances for the walls, ceilings or other structures to which the facade will be fixed will be agreed upon.
- If the tolerances were not aligned during the design, the tolerances given in the following sections of the Building Regulations will continue to apply.
- Allowable structural deviations must be indicated in the design documentation, in the design of the building's constructive work, but must not exceed: attachment of the overlay edge horizontally from the axis + -15mm; and upright + -15mm.
- If the deviations are exceeded, they must be repaired before the transfer of construction part. A contractor who has carried out installation work on supporting structures must ensure that if there are unacceptable variations:
  - respond and make decisions within 24 hours. after informing;
  - They should be arranged within a minimal time frame that is technically compatible with the construction manager.

If the bearing construct deviations according to the fact exceed the permissible projections in the project, then the non-conformity to the project is recorded. The fact of deviations must be recorded in the construction work journal and informed by the responsible project participants (the client or his representative, the general contractor or, if any, the panel of decisions on disputes). Additionally, modifications are made between different contractors with the participation of the contractor or the construction manager or other representative of the customer and the responsibility for the implementation of the changes is determined.

<u>Selection and installation of additional mounting elements</u>

- Before installing the facade system, the compatibility of the planned installation of additional equipment installation with the facade system and the harmonized installation order must be evaluated.
- It is important to evaluate additional elements for fixing, electrical power supply, engineering systems pipelines, air supply or other solutions.
- When creating solutions, it is important to ensure timely and quality mounting process and the possibility of servicing or replacing this equipment when needed.
- These solutions need to be integrated in the design phase and provide design solutions before the facade system is transferred to the production process.
- All solutions for the approval of additional equipment (e. g. blinds, renewable sources, advertising stands, engineering systems, etc.) must be prepared;
- Additional mounting of the equipment to the facade. Attachment of additional equipment to the façade can be carried out only on the basis of the specific installation of the equipment and mounting housings. Additional assemblies must be prepared for unplanned fitting of equipment.
- The equipment must be approved in accordance with the manufacturer's conditions and requirements.
- When fixing additional equipment to the base, its tightness can not be reduced
- Finishing elements can not have sharp corners that can be dangerous in the operation of the facade.

- It is necessary to estimate the heat loss caused by additional elements.

Windows, doors and construction installation works

Inspection of assembled products

Verification of installed windows is performed after the completion of all works provided for in the contract. All works and assembled products from the staff are accepted by the construction manager. At the installation site, check the following locations:

- The assembled product must perform all the intended functions (opening, opening, microwave positions, if any, are foreseen). The product to be opened must function smoothly.

- Visual inspection of window joints with internal and external walls. All joints must not be permeable to water, there must be no cracks between the window and the walls. Verify 400 to 600 mm in good lighting

- The position of the window in the wall (horizontal and vertical) must be checked. The checker uses level and roulette.

- Do not bend or otherwise distort the product frame, sash.

- The built-in sill should be tilted to the room ~ 2 °. The connection to the window must be sealed with an acrylic-based sealant.

- If windows are installed in large lots. It is possible to check quality from one brigade, products mounted on that day, to pick up optional products for several products. If the products in this sample are correctly installed, then it is considered that the whole lot of that day has been installed correctly.

Tools required for checking installed products

Tools Required for Verification of Embedded Products	Control methods	A*	D*	K*
1. Preparatory work:				
- inspection of holes	Volcano, roulette	SV		
- hole preparation		SV		
- materials and products		SV		
- product inspection		SV		
- provision of machinery	SV	SV		
2. Window installation:	SV	TP		
- law, regulation	Volcano, roulette	SV	TP	
- temporary and permanent fixation	Visually	SV	TP	

- sealing	Visually	SV	TP
- gate control	Visually	SV	TP
- window sills installation and sealing	Volcano, roulette	SV	TP
3. Documentation	SV	TP	

Workplace arrangement

- Upon completion of the installation work, the work place is cleaned up, the generated waste is collected in special bags and removed;
- Removing labels and intermediate remnants from mild detergents from assembled window glasses;
- Removed windows are removed as long as it is provided for in the contract with the customer.

Delivery of works to the customer

Upon completion of installation of windows and doors to the customer, the following documents are provided:

- work drawings (if necessary);
- construction works (if necessary);
- acts of hidden works (if necessary);
- Laboratory research (if necessary);
- Documentation of conformity of materials and products;
- The act of transfer and acceptance of works;
- Operation and maintenance instructions.

Roof installation works (Flat roofs)

The control panel for the installation of flat roofs is presented in the tables below.

Table 1. Control of the installation of flat roofs

No.	**Action**	**A***	**K***	How to control	**D***
1.	Preparatory work		TP	Visually	
	- installation of roofing base	SV			TP
	- preparation of coating materials	SV			
	- equipment assembling	SV			
2.	Roofing installation		TP	Visually	
	- installation of slope formation layer	SV			G
	- installation of steam insulation	SV			
	- installation of a heat insulating layer	SV			
3.	Roofing installation		TP	Visually	
	- installation of additional waterproofing layers	SV			
	- installation of waterproofing cover	SV			
	- connecting the cover to the vertical surfaces	SV			
4.	Deformation joints installation	SV	TP	Visually	
5.	Installation of parapets	SV	TP	Visually	
6.	Roof ventilation installation	SV	TP	Visually	
7.	Installation of water drainage from the roof	SV	TP	Visually	

8.	Flooring installation	SV	TP	Visually	
9.	Installation of drainage layer (greened roofs)	SV	TP	Visually	
10.	Installation of a filtering layer (greened roofs)	SV	TP	Visually	
11.	Installation of a substrate layer (greened roofs)	SV		Visually	
12.	Document registration - completion of the construction work journal	SV	TP	Visually	
	- census of hidden acts	SV			
	- Material and product passport control	SV			

A * - responds, K * - controls, D * - participates.

Table 2. Permitted deviations for roof installation

Parameter	Permitted deviations	Control
Base		
Deformations on the surface of the preparatory substrate: along the slope horizontally across the slope in the vertical direction	± 5 mm., ± l 0 mm.	Measuring with bulb
Steam insulation		
Filament seams overlap	> 200 mm	Measuring with roulette
Thermal insulation		
If several layers of insulating products are laid, their joints in relation to the adjacent layers must not match. Interconnections of "cross-linked" heat insulating products are not permitted.	> 100 mm	Visually. Measuring with roulette
The grooves need to be connected in such a way that they form a seamless ventilation duct system	± 5 mm	Visually
Connecting channels manually in thermal insulation	± 5 mm	Measuring with roulette
At the same time - horizontally Vertical direction	- 0,2%; ± 5mm; ±10 mm	Measuring with roulette and bulb
Roofing		
In roof joining areas with walls and other vertical surfaces, the latter must be covered with waterproofing over the roof plane.	> 300	Measuring with roulette
Good adhesion of the coating, both by hot bitumen and by pouring, shows the width of the bituminous mass spreading at a width of about 1 cm.	< 10 mm	Measuring with roulette
Parapets		
The inclination of the top of the parapets must be on the roof	>2,9º	Measuring with bulb
Installation of premises		
Distance between wires	< 12 m	Measuring with roulette

Slope deviation from the design 0.2%	±0,2 %	Matuojant gulščiuku
Ventilation fires		
The vents of the ventilation ducts must be covered in such a way as to prevent rainwater from entering;		Visually
The ventilation openings must be installed every 6-8 meters along the roof ridge and 10-12 m to the roof edge.	± 0,100 mm	Measuring with roulette

Adoption of the construction phase

The quality of roofing work is controlled in accordance with the requirements of the technical regulation, construction rules, design and materials manufacturers' specifications. Only construction products certified in accordance with the established procedure are permitted for roofing structures. When installing roofing materials from roller, film and mastic materials, ad-hoc testing and acceptance are carried out on individual finished elements (steam and thermal insulation, leveling layer, primer, re-intersections, separate layers of waterproofing) and for the entire roof covering. Roofing of unit materials is accepted only after the completion of all work. When controlling the quality of the substrate, it is checked that the materials used, the slope, the water collection points, etc. are in accordance with the project. The roof waterproofing cover must be equipped with the required number of additional waterproofing layers, their layout must comply with the norms and requirements of the project.

Particular care is needed in controlling the quality of the installation of leveling layers on non-rigid and bulk thermal insulation materials. They must be even, firm and stiff, not cracked and free from other defects, which could cause the roller to crack. The acceptance of roofing is formalized by issuing a guarantee passport to the customer. After installing the roof, the SV verifies the work done, writes the relevant act or the results of the inspection in the construction workbook.

The following documents are submitted to the builder upon completion of the completed work:

- Work drawings;
- Construction work journal;
- Acts of hidden works;
- Laboratory research acts;
- Used materials and products passports;
- Inspection and testing acts;
- Examination Act (if required).

Flat roof unexposed roofs

The control plan for the installation of flat roofs is presented in the table.

Table 2. Control of the installation of flat roofs
Abbreviations: SPVP - maintenance of the construction project; SSTP - technical maintenance of the construction of the building; SSV - the head of the construction of the building; A - responsible; D - participant; I - Informed.

No.	Control object	How to control	A	D	I
1	Specification	-Verification of substance compliance declarations - check the compliance of the system elements with the Project	SSTP	SPVP; SSV	
2	Register	checking / approval of the planned construction works and their quantities	SPVP	SSTP, SSV	Užsa-kovas
3	Preparatory work				
	- preparation of coating materials	Visually	SSV	SSTP	
	- equipment assembling	Visually	SSV		
	- preparation of the base	Visually	SSV	SPVP	
4	Roof layout installation	Census of hidden acts for each base layer	SSV	SSTP	
	- installation of slope formation layer	visually, controlling gradients by special devices; cloaking of hidden works	SSV	G, SSTP	
	- installation of a steam insulation layer	visually; cloaking of hidden works	SSV	SSTP	
	- installation of a heat insulating layer	visually; cloaking of hidden acts; visually checking the surface of the surface at a 2m level	SSV	SSTP	
5	Roofing installation				
	- installation of additional waterproofing layers	Visually; cloaking of hidden works	SSV	SSTP	
	- installation of waterproofing cover	Visually, by controlling the bonding of the edges of the strips to the shoulder blade or with a special hook; cloaking of hidden works	SSV	SSTP	
	- connecting the cover to the vertical surfaces	visually	SSV	SSTP	
6	Deformation joints installation	visually; cloaking of hidden works	SSV	SSTP	
7	Installation of parapets	visually; cloaking of hidden works	SSV	SSTP	
8	Roof ventilation installation	visually; cloaking of hidden works	SSV	SSTP	
9	Installation of water drainage from the roof	visually; cloaking of hidden works	SSV	SSTP	
10	Document registration - completion of the construction work journal	checking documents	SSV, SSTP	SPVP	Custo mer
	- census of hidden acts	checking documents	SSV	SSTP	
	- Material and product passport control	checking documents	SSV	SSTP	
MANUFACTURERS RECOMENADTIONS SHALL BE FOLLOWED					

Pitched roofs

The control plan for the installation of sloping roofs is presented in Table 24.1.

Table 24.1. Control of pitched roofs

Abbreviations: SPVP - maintenance of the construction project; SSTP - technical maintenance of the construction of the building; SSV - the head of the construction of the building; A - answers; D - involved; U - customer; I - Informed.

No.	Control object	How to control	A	D	I
1	Specification	- Verification of substance compliance declarations	SSTP	SPVP; SSV	
		- Check the compliance of system elements with the project	SSTP	SPVP; SSV	
2	Register	- Checking / reviewing the construction works and their quantities provided for in the project	SPVP	SSTP, SSV	U
3	Preparatory work				
	- preparation of materials	Visually	SSV	SSTP	
	- equipment assembling	Visually	SSV		
	- preparation of the base	Visually	SSV	SPVP	
4	Roof layout installation				
	- installation of a long insulating layer	Visually; cloaking of hidden works	SSV	SSTP	
	- installation of a heat insulating layer	Visually; cloaking of hidden works	SSV	SSTP	
	- installation of a wind insulating layer	Visually; cloaking of hidden works	SSV	SSTP	
	- installation of anti-condensation layer	Visually; cloaking of hidden works	SSV	SSTP	
	- installation of a waterproofing layer	Visually; cloaking of hidden works	SSV	SSTP	
	-	Visually; cloaking of hidden works	SSV	SSTP	
		Visually; cloaking of hidden works	SSV	SSTP	
5	Roofing installation				
	- Installation of a sloping roof covering	Visually; cloaking of hidden works	SSV	SSTP	
	- installation of sloping roofing	Visually; cloaking of hidden works	SSV	SSTP	
	- installation of sloping roof joists	Visually; cloaking of hidden works	SSV	SSTP	

No.	Control object	How to control	A	D	I
	- connecting the cover to the vertical surfaces	Visually; cloaking of hidden works	SSV	SSTP	
6	Deformation joints installation	Visually; cloaking of hidden works	SSV	SSTP	
8	Roof ventilation installation	Visually; cloaking of hidden works	SSV	SSTP	
9	Installation of water down the slope	Visually; cloaking of hidden works	SSV	SSTP	
10	Document registration - completion of the construction work journal	checking documents	SSV, SSTP	SPVP	U
	- census of hidden acts	checking documents	SSV	SSTP	
	- Material and product passport control	checking documents	SSV	SSTP	
Manufacturers recommendations shall be observed.					

Construction works journal

The progress of construction work (from the commencement of construction to the acceptance of the structure for proper use) is described in the construction workbook. The log shall also record the results and requirements of all inspections carried out by construction inspectors.

www.StatybosZurnalas.lt is a document and process management system for filling and storing the construction works in accordance with STR 1.06.01: 2016 "Construction works. Statutory Construction Maintenance "requirements *. The system allows to keep records of ongoing work in a standardized, prompt, transparent and secure manner. It enables managed access to information related to the construction site, ensures the legitimacy of the construction process, participants and records.

4. Conclusions

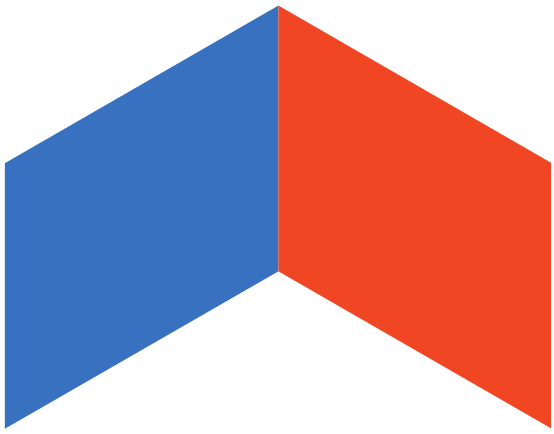
This final version of the report D3.3 presents an overview of the mapping of the most commonly applied quality control techniques in the area of air-tightness and ventilation in the Netherlands, Poland, Lithuania, Spain and France. Also a BIM-enhanced Qualification Framework and methodology is developed, building upon the available results of the related projects adding the cross-trade aspects and interdisciplinary Skills and adding the BIM-process to it, when performing nZEB professional activities. This includes the mapping of which extra skills and competences are needed to optimize the results in nZEB-construction and renovation projects, linked to the professional activities and the workers and professionals involved. This results in an overall nZEB Quality and Skills matrix that is developed in which the five phases in the construction process are discriminated (programme, design, elaboration, realisation, operation & maintenance), and the professions and specialism involves including the levels. The EQF-methodology and guidelines for National Qualification Frameworks will be taken into account. This matrix can be used to fill in the professional activities, related skills and competences needed for each profession/specialism and the related training schemes to acquire the necessary competences.

The initial idea was that in the second half of the project, for each experimental site the BIMplement implementation script should be elaborated and that it will be defined in detail the specific quality control mechanism brought in the specific project stages according to the project needs and its objectives (whether focus on improving air-tightness or ventilation). However, during the second half of the project it was necessary to put the focus on solving the lack of BIM competences on the experimental sites. As a consequence, the BIMplement Model nZEB Cross-trade Quality and BIM-Skills Matrix, although fully in place, could not be actively used as a methodology. Nevertheless, the substantive quality aspects from the qualifications, developed in work package 3, were used in the training sessions and in the mobile training containers.

The BIMplement nZEB Quality and Skills matrix as presented in chapter 1.8 still can (and will) be implemented and elaborated in detail for follow up trainings. This is important as the BIMplement approach and methodology is now actively being used and implemented in several new H2020 projects (for example in TripleA-reno, Save the Homes, re-MODULEES). In these projects it is used to determine the components and/or aspects which are due to quality control and in which phase in the project. Also, it is used to determine the professions/trades and skills that are needed and, linked to that, which competences the involved craftsmen should have (D3.1). In addition, trainings available on a national level (D3.2) to achieve the necessary levels of competences can be linked.

COLOFON

BIMplement



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