Passivhaus Trust
The UK Passive House Organisation

Passivhaus Quality Assurance:

Large and Complex Buildings

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Introduction

The Passivhaus Standard is recognised internationally as the world's leading quality assurance standard for low energy buildings. Unlike conventional buildings, those buildings that are designed, constructed and certified to the Passivhaus Standard have repeatedly been shown to perform "as-predicted" because they have rigorously adhered to stringent quality assurance standards.

The need for this guide has arisen from the rapid growth of the Passivhaus Standard within the UK and the recognition that with the increased volume, scale and complexity of building projects that it takes an increasingly well structured quality assurance system to maintain the required standards of design and construction.

To date, the success of many Passivhaus projects has depended on a motivated client, a dedicated and motivated design and construction team, a high level of specialist knowledge and experience and a close working relationship between all parties, along with a commitment to the successful completion of the project.

Given the culture and context of the UK construction industry, as larger and more complex building projects are realised to the Passivhaus Standard, the development of new, or at the very least more highly refined, quality assurance systems, tools and methods will be required.

Unless these quality assurance risks are addressed, projects could run into a number of serious challenges:

- Costing significantly more money than anticipated
- Running into delays and taken more time to complete than was anticipated
- Failing to achieve the performance standards specified in the contract documents

This purpose of this guide is twofold

- firstly it is to illustrate the need for creating formalised quality assurance tools and methods for buildings that are designed and built to the Passivhaus Standard
- secondly it is to demonstrate examples of quality assurance tools and techniques that are being utilised in practice
- thirdly, with regard to workmanship and liability, it is to confirm and clarify the requirements of the Passivhaus Standard as they relate to construction teams and site managers

Possible Risks for Large and Complex Passivhaus Buildings

The shift towards larger, more complex, mainstream projects brings risks at a number of key stages, namely:

- Procurement processes
- Design
- Construction
- Commissioning

Common risks include:

- Client organisations without Passivhaus experience may not appreciate the step change that the Passivhaus Standard imposes upon the average design team or building contractor. To address this, they would need to:
    - Assess the design team in order to establish the level of experience - of the candidates that they are considering
    - Recognise the extent to which inexperienced design teams will be learning at the clients expense
    - Robustly consider how the experience of delivering buildings to the Passivhaus Standard could inform the cost effective delivery of their project i.e. inexperienced design teams are more likely to create designs that are costly
- Design teams without Passivhaus experience might underestimate the level of skills, knowledge and understanding needed before embarking upon a project designed to the Passivhaus Standard. Designs should consider
    - the cost implications of complex building forms and the increased heat loss arising from poor surface area to treated floor area ratios (poor form factor)
    - the cost implications of thermal bridging arising from an inappropriate building form or poorly specified materials
    - the cost implications that strategic design decisions can have upon critical factors such as the airtightness strategy
    - the time that will have to be invested in learning how to design very energy efficient buildings, which can compromise the quality of service at the vital stages later in the project when the building is on site.
- Building contractors that are inexperienced in constructing to the Passivhaus Standard need to appreciate:
    - the standards of workmanship that are required
    - the ways in which out-of-sequence-activities can lead to increased risk and cost (particularly with regard to airtightness)
    - the implications of substituting materials with different thermal properties
    - the implications of substituting critical products such as windows and ventilation systems
    - the impact that deviations from the contract documents may have upon thermal bridging
    - the need for accurate (seasonal) commissioning and testing of air leakage and building services

- Manufacturers and suppliers of building products need to fully appreciate the quality assurance requirements that are imposed upon them and others, particularly in terms of installation and commissioning.

The essence of the Passivhaus Standard and a quality assurance methodology are described in the document “Claiming the Passivhaus Standard” (INSERT HYPERLINK), which highlights a number of critical components required in order to certify that a building has achieved the Passivhaus Standard. This document describes steps towards a quality assurance process that will help ensure compliance with the Passivhaus standard.

Quality Assurance for Passivhaus Building Projects and Developments

Design Stage: Risk and Cost Control

The greatest capital expenditure occurs during construction. For this reason the greatest observable financial risk is often considered to occur during the building process. This assumption is erroneous.

Whilst not specifically related to Passivhaus Standard the following quote by Dr. Joseph Romm[1] is illustrative:

> "Although building and design costs represent only a fraction of the building's life-cycle costs, when just 1% of a project's up-front costs are spent, up to 70% of its life-cycle costs may already be committed."

The level of influence that a client and a project team have upon a building project is greatest at the beginning. The briefing and design phases represent the most significant opportunity to influence the outcomes. As a project progresses and the design becomes increasingly fixed (say as a result of planning permission) this opportunity rapidly falls.

It should be clear that the foundation of any successful, cost effective building project, whether or not it seeks to achieve the Passivhaus Standard, will be achieved by ensuring that the right project team, with the right experience, is firmly in place from the very beginning.

Passivhaus briefing and procurement reviews are recommended at the end of RIBA Stages 1 and design review audits are advised to take place at the end of RIBA Stages 2 , 3 and 4.

Experienced Certified Passivhaus Designers have developed checklists that they use to manage the design process and filing systems to collate the relevant documentation.

Refer to the "Core Components Of A Passivhaus Project Management Checklist" for the core components of a Passivhaus project management checklist.

From this point forth all other guidance relating to cost management and quality assurance becomes secondary to that of having the most appropriate project team.

The Passivhaus Standard relies upon the PHPP and relevant BS EN standards to verify the performance of materials, products and workmanship. The standard does not impose a formal method for collating and evidencing the documentation that verifies performance. Working in collaboration with one another Passivhaus Certifiers within the UK have developed systems for managing the certification process. Certification is only given once the building has been constructed and all relevant information and evidence has been provided to the certifier.

It is a mistake to assume that compiling the evidence and following these systems alone will mean that your project will be certified. Because certification management systems are only intended to manage the certification process other aspects of the broader building process lie outside of this structure.

[1] Dr. Joseph Romm was acting assistant secretary at the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy during 1997

By failing to recognise the boundary between a certification process and the design and construction process individual projects are at risk and may encounter difficulties.[2]

Core Components Of A Passivhaus Project Management Checklist

Listed below are the major components that are included on a Passivhaus Project Management checklist. Each component, and it's constituent sub-components, should be coordinated with relevant BS EN Standards. When a building is to be certified it is vital that this checklist is developed and agreed with an approved Passivhaus Certifier.

Key stages where photographic evidence of the construction should be gathered by appropriate members of the design and construction team. On a project specific basis the Passivhaus consultant should assist with agreeing the regime for compiling evidence.

Training/ toolbox talks (pre-start)

- Site storage
- Workmanship
- Activities to be undertaken
- Sequencing of activities

Ductwork protected from site debris during storage.

Insulation installation - materials & workmanship

- Walls, Roof, Floor, Windows
- Junctions
- Services

Check construction tollerances. Insulation is encapsulated tightly between internal and external leaf to avoid thermal bypass.

Windtightness - materials & workmanship

- Primary wind barrier system
- Window Installation
- Service penetrations

Airtightness - materials & workmanship

- Primary air barrier system
- Window Installation
- Service penetrations

Air barrier installed in a manner that allows easy inspection and remediation during construction.

[2] In part this may be because the industry has become used to certification systems that are less rigorous and have permitted this gap to go unobserved.

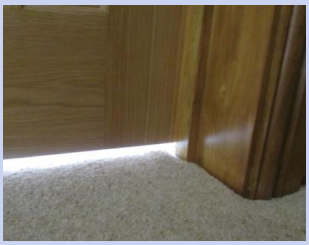
Services - materials & workmanship

- MVHR unit installation
- MVHR ductwork & silencers
- DHW
- Pipes and plumbing
- Heat sources
- Controls

Ductwork protected from site debris during instalation.

Builders Work

- Joinery (door over/undercuts etc)



Air transfer provision is checked against design drawings and specification.

Practical completion (summary report)

On-Site Risk Management for Larger and more Complex Building Projects

Once building work has commenced on site the key to successfully managing project risks and financial risks is to ensure that the site team is appropriately staffed with suitable personnel. To this end they should have been given suitable training and should have responsibility for managing the delivery of specific results.

Experienced Certified Passivhaus Designers that have worked on projects of 20 homes or more have often developed more refined quality assurance systems that those that have only worked upon small projects such as individual homes. They often have experience of providing services such as:

- desktop buildability reviews (comprehensive reviews of construction drawings and specifications, construction programme/sequencing)
- buildability workshops (reviews of results from desktop buildability reviews that include focus groups with the design team, building contractor and site manager)
- tool box talks to provide training for site trades (up-skilling and briefing of trades in specific activities, discussion of sequencing of the works, incorporating further buildability reviews)
- intermittent site inspections (to identify risks), and
- site inspection reports (to record and identify the risks so that they may be mitigated before the next phase of work commences)

Refer to the example Site Inspection Report.

Change Management
During the construction phase it is not uncommon for value engineering and cost cutting options to be considered. With buildings that are designed to achieve the Passivhaus Standard, more so than any other building type, rigorous management tools such as change requests and change order instruction forms. Each change order request should be reviewed by the Certified Passivhaus Designer. Changes that should be tracked include:

- Designs (window/door position within wall thickness)
- Products, materials(MVHR, doors/windows, insulation, airtightness products/systems etc)
- Sequencing (could impact upon airtightness)
- Staff/personnel changes (to manage and track any discontinuity of labour, notably site gangs/trades as this without training this will impact upon quality of workmanship)

In order to minimise financial and project risks intermittent site inspections by an experienced Certified Passivhaus Designer should also be undertaken at agreed intervals. The frequency of these site inspections should be based upon the building type, the construction typology and the duration of the construction programme. Typical considerations will address:

<u>Fabric</u>
1) Below-ground and above-ground fabric
2) Installation of insulation - inc thermal bypass etc.
3) Poor application of insulation at junctions
4) Airtightness of service penetrations

Services

4) MVHR & ductwork installation

5) MVHR commissioning

Process

6) Site storage

It is beneficial for the Certified Passivhaus Designer to be present at:

- pressure test
- MVHR commissioning
- commissioning of other services
- operator/occupant training

Example Site Inspection Report

Project number: 2405 **Project name:** Example Project **Date:** 12/02/13

Weather: Overcast / Dry **Site:** Example Site **Review:** 012

Introduction:

The purpose of this report is to:

- Provide a photographic record of the typical and atypical faults that may impede delivery
- Identify risks that may influence whether the building will achieve the required performance standards
- Identify risks that may impair the successful formation of the air barrier and wind barrier
- Identify thermal bridging and thermal bypass risks that could inhibit as-built performance
- Identify the installation quality of the ductwork and MVHR system, the heating system and where relevant, other building services.

Within the scope of the work, time constraints and availability of access it was not possible to physically inspect all aspects of the building. As site inspections are intermittent, with periods of time between visits, it is recognised that there may be defects that have been concealed during the construction process.

Risk Status:

HIGH	**MEDIUM**	LOW

Progress:

- Client has taken possession of the property though there are a number of outstanding items that need to be addressed.
- User guide has been handed over to client and induction process undertaken.

Observations:

Item	Observation	Recommendations / Comments		Owner
1	Filters have been checked and found to be adequately lean. The extract filter shows staining that suggests saw dust has got into the ductwork.	Replace all filters at the end of the standard maintenance cycle used by the MVHR system.	 	TG

Look Ahead:

1	Address items raised above
2	Inform architect when all of the above defects have been addressed.

Lessons Learnt:

1	A review of the construction drawings should be under taken once the finishes have been installed so as to ensure that ventilation transfer zones are not compromised.
2	Cupped screws should be used to hold architrave at head of door so as to enable easier removal for cleaning.

QA Roles and Documentation for Larger and more Complex Building Projects

Contractor's Declaration

The Passivhaus Standard requires that the construction supervisor for the project make a declaration confirming all deviations and changes that have occurred to the design after the contract documents have been agreed. The declaration should be able to demonstrate that each change conforms to the performance requirements of the initial design.

The need to record and track design changes that may arise from value engineering reinforces the need for a comprehensive change management system that includes input from a Certified Passivhaus Designer.

On large projects where a single person cannot provide oversight for all aspects of the work then it may be reasonable to assign particular roles to individuals.

On-site Quality Assurance Champion

To support the construction supervisor a dedicated, on site quality assurance champion is required. The role of this supervisor is described in greater detail in the Passivhaus Rules of Thumb Guide. With regard to large and complex building projects more than one supervisor may be required.

Contract Documents

Lessons learned from successful projects that have achieved the Passivhaus Standard repeatedly demonstrate a commitment to teamwork. Building contracts that seek to distribute risk in an uneven, burdensome or unwieldy fashion rarely result in a satisfactory conclusion. In fact it often creates uncertainty and leads to inflated costs.

In the context of a construction contract a great amount of time and effort can be spent seeking to allocate blame when in fact it is more productive to approach challenges with a solution based mindset. Operationally a strategic document, something akin to a Memorandum of Understanding (MOU), can provide a more robust framework for working within.

It is in this context that it may be recognised that the purpose of the project team is to identify risks, to allocate costs and then to agree with the client the best method for managing those risks. For this to be possible it means not imposing high level of design liability upon those people, such as subcontractors, that cannot reasonably be expected to understand or appreciate the finer aspects of Passivhaus design before they are engage in a project.

Example Contractors Declaration

Site Address:
Property:
Date:
I hereby confirm that the above property at the above site has been constructed in accordance with the construction drawings and specifications and that all observed defects in workmanship have been remediated in accordance with the site inspection reports.

Conducted Heat Loss

All insulation is continuous i.e. there are no gaps greater than 3mm in front, behind or between the insulation or any adjacent materials.
The conductivity of all materials conform to the specifications.
All workmanship conforms to the specified manufacturer's installation requirements.
Each door and window was inspected upon delivery to ensure conformance with the specification.
All observed defects have been remediated.

Airtightness / Wind tightness

All surfaces were clean, dust free, and dry prior to air/wind barrier tapes being applied.)
During the air test no additional tapes or membranes were place over air leakage points.
Air leakage was measured in accordance with all required standards.

Ventilation

All MVHR intake and exhaust ductwork within the thermal has been insulated in order to mitigate all condensation risks.
All ductwork was protected from dust and debris during construction and that, where appropriate, remediation has been undertake by cleaning the ductwork prior to hand over.
All ductwork was installed in accordance with the MVHR designer's drawings and specifications.
Other than when being commissioned I confirm that the MVHR unit was not left switched on prior to hand over.
The MVHR was commissioned in accordance with all required standards.

DHW

In confirm that all main branches of DHW pipework were insulated.
I confirm that all DHW insulation is continuous i.e. there are no gaps greater than 3mm in front, behind or between the insulation or any adjacent materials.

Name: Position:

Signature:

Company:

Company Address:

Feedback Loops

The best project teams will have experience of designing and constructing buildings to the Passivhaus Standard. They will seek to maintain their working relationships so that they may share learning experiences, consistently refine their understanding and deliver better value.

It is not always possible to re-use the experience of an entire project team. The value of an experienced Certified Passivhaus Designers lies in the fact that they have a deeper appreciation of consequences of designing buildings, reconciling project budgets and reducing risk. As a consequence they are more able to serve the needs of client organisations.

Simply by mitigating costs that less experienced or uninformed designers may otherwise incur experienced Passivhaus designers and consultants could demonstrate their value and offer a return on investment. Harnessing experience over and above Certified Passivhaus Designer Qualifications should therefore be considered.

Conclusion

This document has reviewed the need to clarify the quality assurance requirements of the Passivhaus Standard in order to facilitate the development of increasingly large and complex building projects. To facilitate this it has drawn upon experience from both small and large projects. It has also described a framework that enables clients, designers and contractors to reduce financial risk and increase the level of certainty about the success of a given project. Finally, by describing the contractor's declaration, it has provided contractors with a greater appreciation of their role within the certification process and the liability that they assume for the success of the building.