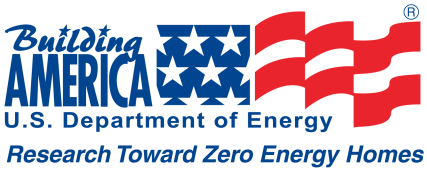

Quality Assurance Roadmap for High Performance Residential Buildings

Building Science Corporation Industry Team

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Submitted By:
Building Science Corporation
70 Main Street
Westford, MA 01886

Principal Investigators:
Joseph W. Lstiburek, Ph.D., P.Eng. ASHRAE Fellow
Betsy Pettit, FAIA

Phone Number: 978-589-5100
Fax Number: 978-589-5103
E-Mail: joe@buildingscience.com
E-Mail: betsy@buildingscience.com

Submitted To:
U. S. Department of Energy
National Energy Technology Laboratory
PM: Rob Martinez

E-Mail: Rob.Martinez@NETL.DOE.GOV

Quality Assurance Roadmap for High Performance Residential Buildings

Alex Lukachko, Building Science Corporation

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Abstract

BSC's Quality Assurance Roadmap outlines the approach to quality assurance in the construction process as recommended by Building Science Corporation for new residential construction. Seven process steps are described from the assessment of current construction practice, through design and documentation changes, to training and quality control for on-site personnel. This document is intended to be used in lieu of a formal QA process to support high performance construction in Building America Research Prototype houses.

Quality Assurance Roadmap for High Performance Residential Buildings

This document outlines the approach to quality assurance in the construction process as recommended by Building Science Corporation for new residential construction.

The seven steps given below are meant to provide a "roadmap" for builders who intend to integrate whole house construction improvements aimed at the construction of more energy-efficient, durable and affordable buildings. The approach is intended for builders constructing high-performance Building America prototypes but has general application for high-performance construction.

The roadmap is processed-based, not technology-based. This document accompanies the BSC Building America Performance Criteria, which provides minimum performance levels for new residential construction.

These are the seven steps:

1. Review of past construction and risk assessment
2. Setting performance goals
3. Changes to drawings, specifications, contracts and trade scopes-of-work
4. Training for site supervision and trades
5. On-site inspections, verification, and trouble-shooting
6. Commissioning
7. Post construction evaluation

In Building Science Corporation's experience working with large and small builders across the United States, all of these steps deserve a high degree of attention. The steps provided here are guidelines – it is expected that each builder will require a process that is heavily customized to suit internal goals, technical challenges, and regional variation. However, the seven steps provide a starting point or minimum standard for builders who build high performance houses.

The importance of "buy-in" from top levels of management cannot be over emphasized. We have found that the technical changes to the construction process are relatively straightforward if they are well supported by the builder's internal organization and, most importantly, commitment from the trades performing the work.

Each of the steps is described in more detail below.

1. Review of past construction and risk assessment

All builders should conduct a review of construction techniques with qualified third-party teams. This review has two goals: to provide a "baseline" for future decision-making, and to identify specific performance problems. The third-party assessment team should be multi-disciplinary and be capable of analyzing construction techniques, building performance, delivery process and logistics, as well as business structure.

Suggested steps

1. Assessment of typical plans and specifications ("Front-end assessment")
2. Two construction "walks" with third-party review team. The first is to be conducted with the builder's ownership or senior management. This is followed by an assessment period (usually one overnight session). The second "walk" should include managers and site supervision.
3. Performance testing of current construction to establish quantitative benchmarks for analysis and future comparisons
4. Analysis of callbacks, warranty claims, and buyer surveys. Frequency of construction defects should be recorded. ("Back-end assessment")
5. Report to management, followed by ongoing monitoring of performance testing, construction defects, and callbacks.

Further reading and other resources

- *Building Science Digest 144: Increasing the Durability of Building Constructions* – this document offers an overview of building failures and gives an approach to durability planning. The document can be viewed online or downloaded at: http://www.buildingscience.com/documents/digests/bsd-144-increasing-the-durability-of-building-constructions
- *Process and Energy Efficiency Review (PEER)* – developed for the US DOE Energy Efficient Industrialized Housing research program, the PEER process is a three-day review of a manufactured homebuilder's operations in several key categories: energy, manufacturing and design. The following link to one of the PEER reports contains useful information for all builders undertaking a operational review: www.baihp.org/pubs/pre2000/process/index.htm

2. Setting performance goals

The results of the construction practices review should be integrated into a set of performance goals that can guide decisions on technology and building practice changes. Goals may include some or all of the following:

- Energy or resource use reduction
- Extending building durability
- Construction cost reduction
- Increased homebuyer satisfaction
- Reduced risk and liability

Suggested steps

1. Identify areas for performance improvements and prioritize action
2. Set performance targets
3. Develop high-performance building specification or "product brief" to meet these targets
4. Communicate these results to personnel and trades

Further reading and other resources

- *BSC Building America Performance Criteria* – this document is maintained by Building Science Corporation as a minimum performance standard for Building America projects. This standard represents a performance level that is achievable to production builders with some effort. The current version of this standard can be found at: www.buildingscienceconsulting.com/buildingamerica/targets.htm
- *Building America Builder's Challenge Criteria* – is the core standards document for a program has been developed by the US Department of Energy's Office of Energy Efficiency to challenge builders to build better housing. The standards represent a level of performance that should be very achievable for most builders. The criteria can be found at: www.buildingamerica.gov/challenge/
- Many green building programs set appropriate targets for high performance residential buildings. Here are several well known programs:
  -USGBC *LEED for Homes* – www.usgbc.org
  -ANSI-NAHB *National Green Building Standard* – www.nahbrc.org
  -Southface Institute *EarthCraft House* – www.earthcrafthouse.com
  -Masco *Environments for Living* – www.eflhome.com
- Home Energy Rating System (HERS) – a HERS rating and the rating process can be a useful way to set and achieve energy performance targets. The HERS rating is a core component of the US EPA's ENERGY STAR program for new houses. More information about ENERGY STAR can be found at: www.energystar.gov

3. Changes to drawings, specifications, contracts and trade scopes-of-work

Expectations for trades need to be laid out clearly in the builder's contract documents and reinforced through discussion, verification and feedback. For any builder, these documents are the paper versions of more complex relationships. Changes, therefore, need to be as much "people-based" or "knowledge-based" as they are "paper-based." The process for making these changes is not unusual but it should be pursued in an unusually systematic way.

Suggested steps

1. Review high-performance building specification or product brief with product designer(s)
2. Modify product design to meet performance expectations
3. Internal review of proposed changes (Purchasing, Construction, Customer Service)
4. Secure trade and subcontractor input on changes to design and contract documents
5. Revise specifications, drawings and contracts to reflect high-performance building specification and include input from all stakeholders in the process

Further reading and other resources

- IBACOS BA High Performance Scopes of Work is a model for revisions to contract documents. The document includes specific contract language and a description of a complete process for overhauling builder-trade relationships to support high performance construction. The document is available at: www.ibacos.com/pubs/High_Performance_Scopes.doc
- NAHB Trade Contractor Quality Control Manual – This resource provides a general approach for builders to involve their trades in a quality control system. The Manual can be found at www.toolbase.org/Best-Practices/Business-Management/Trade-Contractor-Quality-Control
- *Builder's Guides* (available for all climate zones) by Joseph Lstiburek – the builder's guides are climate-specific design and construction guides for builders of high performance homes. The house-as-a-system approach gives building science advice on house performance and specific building details. These publications are available at: www.buildingsciencepress.com
- Building America Best Practices Guides – Five climate-specific guides have been created by the Department of Energy to collect the best practice recommendations of the Building America program. These documents can be downloaded from: www.buildingamerica.gov

4. Training for site supervision and trades

Training for supervision and trades is critical but training should begin far upstream of the construction site. Group training sessions with multiple trades present have been found to be a vital part of implementing high performance measures that affect the whole house (and therefore are constructed by several different trades). At group training sessions, all efforts should be made to have those who will be performing the work, as well as, their supervisors and the builder's site supervision staff at hand. Plans should be made for continuous support after construction has started to ensure that learning is done "on the job." Finally, homeowner training of some form is necessary to ensure that the benefits of the high performance home are realized.

Suggested steps

1. Internal training for management, site supervision, sales and marketing, and customer service
2. Trade group information sessions (see description below)
3. Plan for continuous support throughout construction phase
4. Conduct homeowner training for purchasers before handover

Further reading and other resources

- Trade group information sessions are pre-construction meetings involving the builder's site inspection and QC team and all of the trades involved in an identifiable phase of the construction. These meetings are necessary to discuss the technical and process requirements for high performance buildings and to identify the procedure by which each trades' work will support the performance goals. These meetings will cover:
    - the overall project goals and trade obligations
    - the scope of work for each trade, highlighting expectations
    - information and training for new or unconventional practices
    - the process for on-site co-ordination, inspections and remedial work

- NAHB "Hot Spot" Training – Acknowledging that defects are not occurring randomly and that they occur where the work is performed, Hot Spot training has been designed by the NAHB Research Center to identify repeating problems, address these problems through continuous on-site training as the work is being performed, and to provide feedback for continuous quality improvement. Tools for builders and tools for trades are provided, with excellent advice on how this fits into the total quality management system. More information can be found at: www.toolbase.org/Best-Practices/Business-Management/Hot-Spot-Inspections

- NAHB Research Center *Implementing a Quality Assurance System: A Trade Contractor Case Study* – This case study documents the process of introducing QA systems to trades and described the results. The full case study document can be downloaded from: www.toolbase.org/Best-Practices/Quality-Management/implementing-quality-assurance

5. On-site inspections, verification, and trouble-shooting

On-site inspections should be a normal part of the site supervision and quality control routine for the builder. For high performance housing, specific inspection points may be different that those typically examined. In addition, performance tests will likely be used to verify whole house characteristics (enclosure airtightness, for example). All trades should be familiar with the additional inspections and should understand that verification of building performance is a necessary part of high performance building.

Suggested steps

1. Follow-up off-site training (step 4 above) with on-site review for trade crews
2. Set an on-site yardstick for quality using the construction of model homes
3. Perform inspections and verification with standardized documents that are readily available to all site personnel (see BSC BA Quality Control Checklist)
4. Provide immediate feedback to trade crews

Further reading and other resources

- BSC Building America Quality Control Checklist – has been developed as a basic quality control tool for builders involved in the Building America program. The checklist can also be used for design, contract negotiation, training, and homebuyer assurance. The checklist and instruction documents can be downloaded at: www.buildingscience.com/QA

6. Commissioning

Basic commissioning of mechanical systems and other equipment is a requirement for high performance housing. For some advanced system such as combination water/space heating systems, ground-source heat pumps, solar thermal systems and photovoltaic arrays, special commissioning measures will need to be taken. Basic commissioning activity should be completed prior to handing over the home to the homeowner. Provide feedback on commissioning results to installers. Provide information and training for homeowners about how their new home is expected to be operated. Both of these steps are also effective long-term risk reduction strategies for the builder.

Suggested steps

1. Develop a commissioning plan appropriate to the equipment installed
2. Review commissioning results with installers
3. Provide homeowner with information on the proper operation and maintenance of mechanical systems and other equipment (see BA Model Homeowner's Manual)

Further reading and other resources

- Air Conditioning Contractors of America (ACCA) *HVAC Quality Installation Specification* – ANSI/ACCA 5 QI-2007 provides guidance on the proper commissioning of residential mechanical systems. A download and more information can be found at www.acca.org/quality/
- BSC BA "SNAPSHOT" testing form – the Short, Non-destructive Approach to Provide Significant House Operation Thresholds (SNAPSHOT) document is a test form used in the Building America program to ascertain house performance and specifications. The inspection form and instructions can be downloaded at: http://www.buildingscience.com/documents/reports/rr-0413-the-snapshot2014a-quick-description
- Building America sample homeowner's manual – a sample manual containing information on proper operation and maintenance was prepared for the EcoVillage project in Cleveland, OH. This document can serve as a guide for a project-specific manual. The manual can be downloaded at: www.buildingscience.com/documents/reports/rr-0310-ecovillage-homeowner-handbook

7. Post construction evaluation

To ensure that goals are met, follow-up information gathering and analysis is required. This is a fundamental part of a continuous quality improvement system and a natural step to achieve a high degree of customer satisfaction. For the builder, post construction evaluation is a means of confirming improvements and a source of information for future decision-making.

The construction improvements implemented will determine the appropriate method of post-construction evaluation. In general, quantitative measurements should be developed for all key performance goals. Here are some examples:

Example measures

- Customer satisfaction and behavior surveys to prioritize corrective action and discover construction defects
- Analysis of construction defects and callbacks
- Voluntary home inspections to verify home performance after a period of service under occupied conditions and assess the effectiveness of durability measures
- Long-term energy use monitoring to confirm predicted energy use and troubleshoot problems
- Re-commissioning of mechanical systems

Further reading and other resources

- Facility Performance Evaluation – The Whole Building Design Guide has collected information on Post Occupancy Evaluations for non-residential buildings but many of the same approaches apply to high-performance housings. For more information, see: www.wbdg.org/resources/fpe.php

Other resources

There are many complete quality management system and internationally recognized standards for quality assurance and quality control. To produce buildings with consistently high levels of performance—i.e. that are more durable, more energy-efficient, more comfortable, more environmentally responsible and are a better product for the builder—we recommend that all builders integrate a quality management approach that makes continuous improvement a core operational value.

Below is an index of the most common or widely used programs. A builder's organization may need a custom approach to fit their business structure – these standards and resources are designed to accommodate this.

- NAHB Research Center *National Housing Quality (NHQ) Certification* is a continuous improvement program for builders. For more information see: http://www.nahbrc.org/builder/quality/certifiedbuilder.aspx
- ISO 9000 is a set of guidelines for quality management systems that can be applied to home building business practices. More information: www.iso.org
- Total Quality Management (TQM) is a management approach to integrating quality assurance and quality control systems into all aspects of an organization's structure. Many resources exist for this topic. A good review of TQM for construction can be found here:
- Plan-Do-Check-Act (PDCA), a cyclical approach to quality improvement, is described here: en.wikipedia.org/wiki/Shewhart_cycle
- Quality Function Deployment (QFD) is a planning tool used to integrate customer feedback into design decisions. For more information, see: Akao, Yoji. *Quality function deployment: Integrating customer requirements into product design*, Cambridge, MA: Productivity Press, 1990.
- The "Quality Circle" approach is a useful model for trade/supervision training and quality control. 'Circle' members are encouraged to discuss improvements and make recommendations for process changes. Open feedback is a core characteristic of Quality programs.