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Final Report of Quality Assurance Activities for New Homes
(Interim Project Report)

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Prepared For:
Midwest Research Institute,
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401-3393

Prepared By:
NAHB Research Center
400 Prince George's Boulevard
Upper Marlboro, MD 20774

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QUALITY RESEARCH FOR NEW HIGH PERFORMANCE HOMES

Introduction to Quality Research for New Homes

This report is an interim report by the NAHB Research Center regarding their quality management activities for new high performance homes from January 2010 through June 2010. It is a summary and an overview of four full individual reports included in the Appendices. The report includes the NAHB Research Center's current quality research products for new home construction.

Background of Quality Research in Building America

Historically, the focus of the Building America (BA) program has been the "technical best practices" – specifications, general design and engineering strategies, and construction techniques, that, when implemented properly, lead to high performance homes. As the BA program matured, it became evident that many operational aspects of a building company must be aligned to consistently deliver high-performance homes on a production scale. This, in turn, led to the development of a five-year plan to merge high-performance technical specifications with effective quality management systems (QMS) and resources, customized to the specific needs of high performance home construction. The current quality research agenda within BA is designed to support builders' and remodelers' efforts to effectively and efficiently meet the BA energy performance targets.

Research Products for New Homes in this Report

The NAHB Research Center's current Building America new home construction quality management work is comprised of developing tools and resources for builders. The research products included in this report address the value and economics of quality, integrating high performance and quality management, scopes of work, and addressing recurring issues. The specific research products include:

1) Economics of Quality: The Implementation and Economic Impact of Quality Management in the Homebuilding Industry Research Paper
2) Veridian Homes Quality Management Case Study for High Performance Homes
3) Final Scope of Work for Vented and Unvented Crawlspaces
4) Hotspot Implementation Guide and Tools

Economics of Quality: The Implementation and Economic Impact of Quality Management in the Homebuilding Industry

To ensure that high performance homes are built as designed to achieve Building America energy performance targets, a builder's quality control and quality assurance processes are necessary. However, there are economic costs that can directly affect the economics of energy efficiency upgrades in a high performance home. To address this, the NAHB Research Center developed The Economics of Quality: The Implementation and Economic Impact of Quality Management in the Homebuilding Industry Research Paper (The Economics of Quality). The paper examines the value and impact of quality across industry in general, then on the construction industry, and finally within the homebuilding industry and specifically high performance homes. The full Economics of Quality paper is located in Appendix A.

In addition to its obvious effect of improving quality, the value of quality management is that it can have a net positive financial impact on a builder's operations. Determining the costs of and profits resulting

from quality efforts allows a high performance home builder to optimize the costs of the prevention of defects through appraisals to reduce the number of failures. There is also a direct connection between quality management and increased customer satisfaction. Numerous manufacturers, builders, high performance home builders, Malcolm Baldrige National Quality Award winners, National Housing Quality Award (NHQA) winners have documented value of quality management, cost savings, increased customer satisfaction, and other benefits of implementing quality management systems. In addition, to help builders implement quality management, there are many tools available including the NHQA application process.

The Economics of Quality paper also addresses the importance of quality performance metrics for builders and which performance metrics might be appropriate for the industry to adopt. The goal of performance metrics for quality management is to quantify the results of high performance home builders implementing quality management systems. To meet this goal, it is important to document schedules, energy performance, costs, training, satisfaction, referrals, productivity, and warranty/defects. The data from the performance metrics is vital to demonstrate to high performance home builders the significant impacts that an effective quality management system can have on energy performance, financial performance, construction schedules, etc.

Consistently measuring these metrics will allow a builder to determine where they are at and areas for improvement. In addition, this will allow a larger study of quality management including value, costs, energy and quality performance, customer satisfaction, and the value and impact in the construction industry. Those builders that have already adopted these practices have seen significant improvements in the performance of their businesses. This research has been developed to address a need in the industry to explain and justify the economic benefits of quality management activities.

Veridian Homes Quality Management Case Study for High Performance Homes

As a complementary effort to the Economics of Quality paper, the NAHB Research Center developed the Veridian Homes Quality Management Case Study for High Performance Homes (Veridian Homes Case Study). The full case study is located in Appendix B. This case study builds on the Economics of Quality research paper by providing a detailed look at many of the quality initiatives that have been effectively implemented by Veridian Homes and that have resulted in successful energy, business, and quality results. The case study provides builders with an up-close view of the types of quality activities that they might consider implementing, as well as the impressive quality and financial results that these types of quality initiatives can create. This case study shows Veridian's success with the integration of high performance homes with quality management systems.

Veridian Home's success did not happen overnight, but rather it was a gradual process through continuous improvement. The key to the company's success was the decision to adopt and adapt management tools and techniques to improve energy efficiency, cycle time, and employee and customer satisfaction, as well as to reduce defects and cost. Over time, these changes led to continual product improvement. Whether it's in design, construction, or safety, process improvement is at the core of the company's success. All of these have been driven and coordinated with a focus on designing and building High Performing Homes and managing the entire business on process improvement at every level.

Final High Performance Scope of Work for Vented and Unvented Crawlspaces

As part of developing Building America high performance homes quality management tools the NAHB Research Center also developed final High Performance Scopes of Work for Vented and Unvented Crawlspaces. The full document is included in Appendix C. A Scope of Work (SOW) is a description of the work that a trade contractor will perform for a builder. Every contract, even if only verbal or implied, incorporates a SOW. However, without a clear, detailed, written agreement between the builder and trade contractor, there cannot be any realistic expectation of performance because both parties often have significantly different expectations of the work.

These two SOW for Crawlspaces are part of a series of high performance Scopes of Work for new homes under development. These SOW are designed for high performance homes built in the mixed-humid climate and are more comprehensive than typical ones. Specifically the SOW includes specifications for high performance homes such as details. For example, they include sequences of work, inspection checklists, and architectural details. The Scopes of Work will be available online at ToolBase (ToolBase.org) in downloadable and modifiable formats to enable builders to use them as is, or to customize to their particular geographical or business needs.

Hotspot Implementation Guide and Tools

The goal of implementing a quality management process for BA high performance homes is the prevention of problems, issues, and defects. While prevention is the ultimate goal, part of a quality management process includes managing issues that do occur effectively to prevent their recurrence. The Hotspot Implementation Guide and Tools report was developed by the NAHB Research Center to address recurring issues. The full report is located in Appendix D. This is of particular importance in high performance homes because the home must work as a system to achieve the desired energy performance without issues regarding durability, moisture, indoor air quality, comfort, etc.
The hotspot process begins by first identifying the recurring issues a specific builder is experiencing. A hotspot is often found by reviewing data such as warranty data or customer complaints. Following this, the identified hotspots then need to be prioritized to be addressed one at a time. Then the cause of the issue needs to be determined to create a solution. Next, the solution needs to be communicated, implemented, and then monitored for impact. By eliminating hotspots, costs can be reduced, profits increased, and customer satisfaction improved, and ultimately the company is made stronger and more sustainable.

The hotspot process is a quality management tool that was developed under the NHQ Certified Trade Contractor Program to support quality efforts to prioritize and greatly reduce recurring problems. The experience of NHQ staff with the hotspot process was that those companies who effectively implemented the process were rewarded for their efforts and were able to greatly reduce their recurring quality problems. The intent of the Hotspot Implementation Guide and Tools is to provide a resource for builders and their trade contractors that allow them to take on a very important element of a quality management system and to reap its benefits almost immediately. In addition, the Hotspot Implementation Guide and Tools is a self-contained quality management process and is not dependant on having a formal quality management system in place. Therefore, it can be used by high performance home builders as an incremental step to a formal quality management system.

Appendix A: The Economics of Quality

The Implementation and Economic Impact of Quality Management in the Homebuilding Industry

1. Introduction. What is the Cost of Quality?
2. The Economics & Value Impact of Quality
3. Quality in the Construction Industry
4. The Impact of Quality for Home Builders
5. The Impact of High Performing Homes
6. Suggested Quality Management Tools and Techniques for Home Builders
7. Suggested Metrics for Home Builders Measure and Monitor Cost of Quality
8. Conclusion
9. References

Introduction

With high performance homes, energy performance and cost savings are quantifiable. Energy performance in the Building America program is estimated in the design phase using energy simulations and verified through testing and monitoring. In addition the economic cost benefits of energy efficiency for both the builder and ultimately the homeowner are also quantifiable. One Building America goal is that for each high performance home the amortized costs of energy efficiency upgrades is less than that of the monthly utility bill savings. The result is a home that is more energy efficient and is cost effective for a homeowner to buy and operate.

Cost of Quality Definitions

Prevention: Cost of all activities specifically designed to prevent poor quality in products and services.

Appraisal: Costs associated with measuring evaluating or auditing products or services to assure conformance.

To ensure that the homes are built as designed to achieve optimal energy savings, a builder's quality control and assurance processes are necessary. There are economic costs to a builder for quality management including the costs for prevention, appraisal, and the cost of failure that can directly affect the economics of energy efficiency upgrades in a high performance home. An effective quality management system should create efficiencies and related savings that are greater than the investments in the quality activities required to achieve the savings. However, the costs of quality are difficult to measure due to the fact that the performance metrics have not been fully defined and are often not effectively utilized by builders.

The goal of this paper is to detail the value of quality management in general as well as specifically to new home construction and high performance homes. Therefore, the paper outlines the economics of quality including the cost of quality which breaks down the impact of quality into its component parts, its value, its impact in the construction industry, and its value for high performance homebuilders. In addition, it lays out recommended tools and techniques for the introduction of quality management and the monitoring of its impact based on metrics. Those builders using these tools and techniques have seen dramatic improvements in energy and quality performance, profitability, and customer satisfaction.

Definitions (cont.)

Internal Failure: Costs resulting from products or services not conforming to requirements or customer user needs, which occur prior to delivery or shipment to the customer.

External Failure: Costs resulting from products or services not conforming to requirements or customer / user needs which occur.

The Economics & Value Impact of Quality

The economics of quality include the fact that there are costs to prevention, appraisal, as well as costs of failure. Ultimately the goal is to be able to track the costs and benefits of each to determine the most cost effective solution. The cost of quality (COQ) relates to the costs of Prevention, Appraisal, and Failure (PAF). The COQ can be further broken down into the cost of good quality (conformance) and poor quality (non-conformance) as shown below (*Cokins*, 2006).

Cost of Conformance (good quality) = **Prevention Costs + Appraisal Costs**
Cost of Non-Conformance (poor quality) **= Internal Failure Costs + External Failure Costs**

In other words, the cost to achieve high quality consists of the cost to prevent errors plus the cost to monitor or appraise performance to detect errors. The cost of poor quality (non-conformance), on the other hand, is equal to the cost of correcting failures before delivery to the customer (Internal Failure) and the cost of failures after delivery to the customer (External Failures).

Figure 1 shows how the cost of poor quality or chronic waste can be reduced by focusing on the three fundamentals of quality, planning, control and improvement.

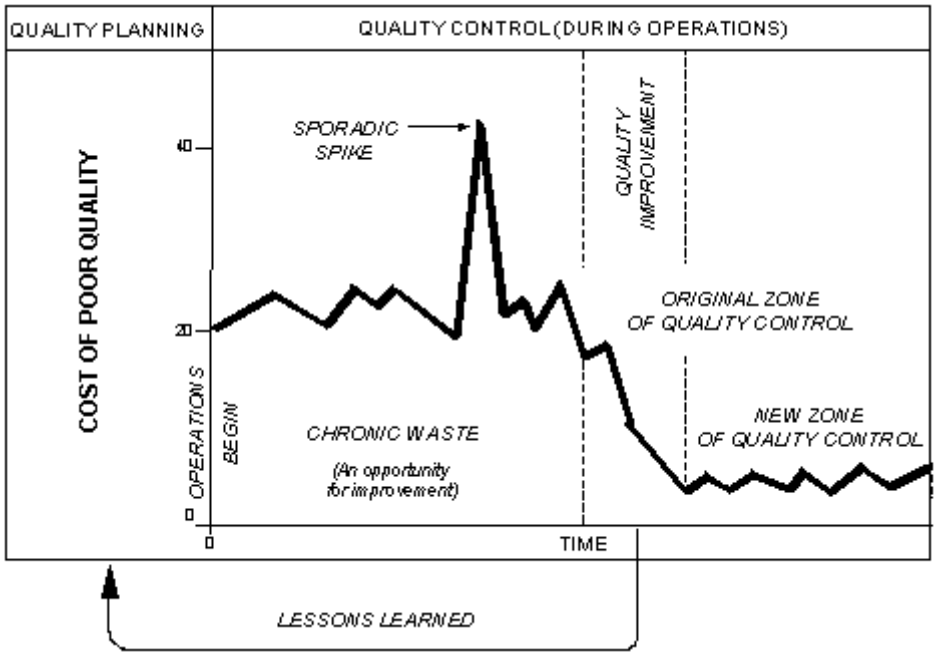


Figure 1. The Juran Trilogy

Examining the PAF (Prevention, Appraisal and Failure) model graphically, (Figure 2) total quality costs are the sum of prevention, appraisal, and failure costs. The cost of failure decreases as the cost of prevention and appraisal rises with increasing quality, there is typically a minimum point along the total cost curve. This point represents the ideal investment in prevention and appraisal that will present the least total quality cost. Below that investment in prevention and appraisal, failure costs—and, hence the total cost of quality—will be high. By contrast, investing too many resources in prevention and appraisal will reduce failure rates, but at an excessive cost. When embarking on a quality management program, companies which wish to minimize the total COQ invest the optimal amount in prevention and appraisal that provides the maximum return on investment with respect to failure costs.

The goals of a quality program include reducing the overall COQ and to invert its components such that the majority of costs are spent on preventing and catching defects rather than correcting failures. But obviously the aim is to then also reduce the cost of prevention and appraisal also. Figure 3 depicts the hypothetical COQ, including its component costs, for a corporation before and after quality program implementation.

Understanding the cost of quality and its potential impact are two of the most fundamental aspects of quality management.

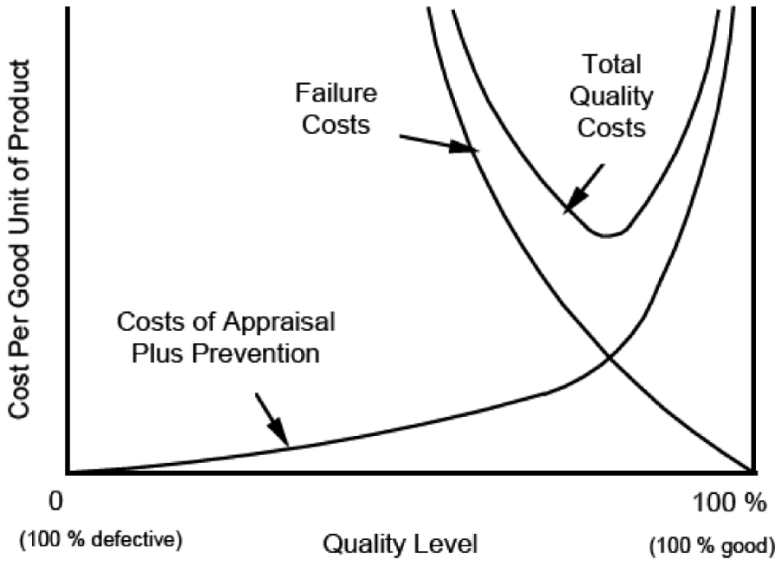
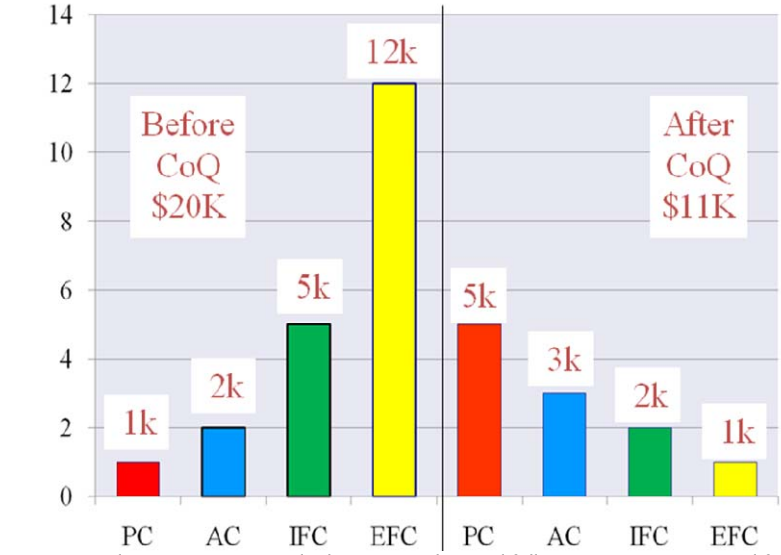


Figure 2. The classical COQ model



PC=prevention cost; AC=appraisal cost; IFC=internal failure cost; EFC=external failure cost

Figure 3. Hypothetical cost of quality (*Cokins*, 2006)

The Impact of Quality

Beyond the costs of quality, there it the impact of quality on revenue and reducing the total cost of quality (TCOQ) by increasing preventative costs and decreasing failure costs. There is ample evidence of the strategic importance of quality management and the positive impact it has on businesses due to its systems approach, focus on the customer and links to strategic planning and competitive advantage (e.g., *Cokins*, 2006, Harrington, et al., 1999, *Easton and Jarrell*, 1998, *Cable and Healy*, 1996).

One study (*Samson and Terziovski*, 1999) examined quality management practices and operational performance at 1,200 Australian and New Zealand manufacturing companies. Researchers identified a

statistically significant relationship between quality management practices and operational performance with the strongest predictors of performance being leadership, personnel management, and customer focus. These factors and their correlation to rates of return are supported in numerous other studies. For example, *Evans and Jack (*2003) found that improving quality management practices had a positive correlation with financial performance. A 1998 study of 307 companies in 50 US states also found that quality driven strategies improved financial performance. In other words, investing in quality management techniques leads to increased profitability (Handfield, Ghosh and Fawcett, 1998). A study of Swedish national quality award recipients found a significantly higher return on assets than their competitors and a comparable group (*Eriksson and Hansson*, 2003).

In a study of 63 manufacturing organizations *(Rodchua,* 2009), the total cost of quality was shown by to be between 8% and 10% of expenses or between 2.6% and 4% of sales revenue. Failure costs among the organizations studied represented between 70% and 80% of the total cost of quality (Figures 4 and 5).

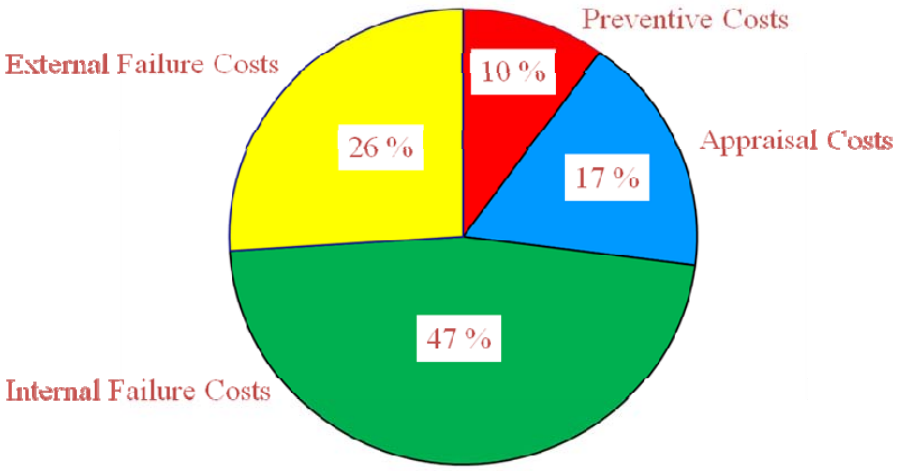


Figure 4. COQ in small to medium-sized organizations (*Rodchua*, 2009)

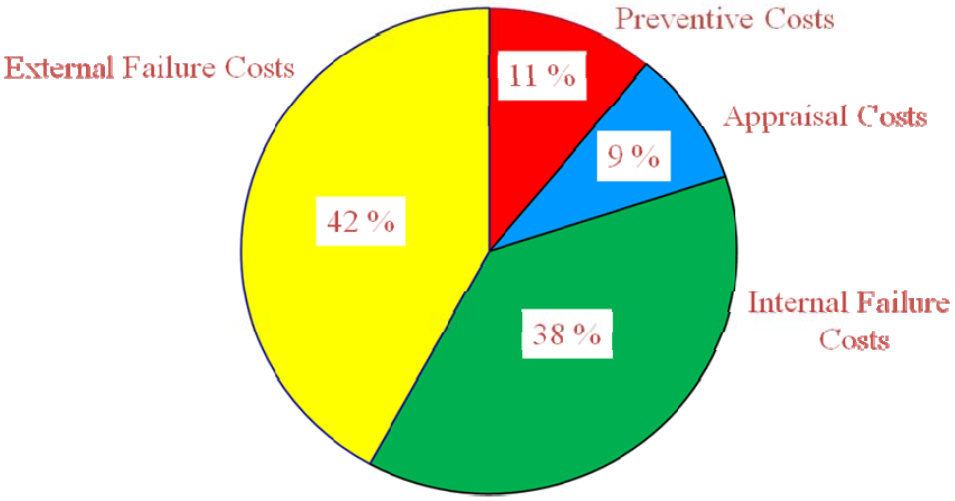


Figure 5. COQ in large-sized organizations (*Rodchua*, 2009)

Schiffauerova and Thomson (2006) showed that the total COQ can be reduced by introducing quality management processes. In their study, organizations which introduced quality management reduced the total COQ by:

- 25% in one year (Hewlett Packard, PC manufacturer)
- 65% to 15% in eight years (Raytheon, electronics)
- 35.8% to 18.1% in four years (Philips, semi-conductors)
- 23.3% to 17.3% in five years (United Technologies, telecommunications)

These studies provide clear evidence that quality management can yield significant returns on investment.

Customer Satisfaction Starts from Within

In addition, reducing the failures and the associated costs has the benefit of increasing customer satisfaction. It has been long established that organizations with a focus on quality management achieve high levels of customer satisfaction (*Nilson, et. al*, 2001). Research has shown that a key driver for customer satisfaction is employee satisfaction. *Bernhardt, et al.* (2000) report a "positive and significant relationship between customer satisfaction and employee satisfaction," while *Brown and Lam* (2008) describe the relationship as "positive and statistically and substantively significant." Concludes *Lee et al.* (2008), "Employee satisfaction is significantly related to service, quality, and to customer satisfaction, while the latter in turn influences firm profitability…leading to a satisfaction-quality-profit cycle."

Harter et al. (2002) studied 7,939 business units in 36 companies and found that businesses that had employee satisfaction ratings in the top 25% had, on average, 1% to 4% higher profitability and similarly higher productivity (revenue or sales per month), as well as between $80,000 and $120,000 higher monthly revenue.

Satisfied employees, are more productive, innovative, and loyal which, in turn, leads to customer retention. *Yoon et al.* (2002) suggest that employee satisfaction plays a "strong, central role" in predicting profitability and *Koys* (2006) further relates it to "organizational effectiveness."

So what are the elements that drive employee satisfaction? In a study of over 5,000 employees across 90 companies, *Cozzani and Oakley* (2005) are the three key elements leading to employee satisfaction.

- organizational communication
- employee engagement and
- organizational culture

To effectively connect employee and customer satisfaction, the Corporate Leadership Council advises that "companies must build their own models because customer satisfaction is only one variable in understanding the relationship between employee satisfaction, customer satisfaction and financial performance. Moreover, each company must determine how it defines employee satisfaction and customer satisfaction, which can even differ between departments and business units within one company," (Corporate Leadership Council, 2003).

The Impact of the Malcolm Baldrige National Quality Award Criteria

Companies successfully implementing quality management are typically businesses that are recognized for their successes. Since its inception in 1987, the Malcolm Baldrige National Quality Award (MBNQA) has generated substantial interest in the benefits of quality management and has served as a motivator for implementing quality management systems. The program, created to stimulate quality improvement by U.S. manufacturers, recognizes achievement, establishes criteria for evaluating improvement, and publicizes the practices of award-winning companies in order to educate others. In its 23 years, there have been more than 1,300 applicants, 72 award recipients, 2,800 quality examiners trained, and 750,000 copies of its Performance Criteria for Excellence distributed. It has inspired the creation of 43 state awards and nearly 45 international quality award programs. This reflects the international success, rate of adoption and impact of the MBNQA. Many of the research studies cited here, as well as many others, have been carried out using MBNQA winners, applicants, and companies which use its Criteria for Excellence to drive improvement.

MBNQA applicants and winners consistently outperform other companies in key metrics. For example, the U.S. Commerce Department compared return on investment for MBNQA winners to S&P 500 index companies. Between the years 1988 and 1994, MBNQA winners had 188% ROI compared to 28% for the S&P 500 companies (*Jacob et. al*, 2004; *Ramasesh*, 1998).

These exceptional returns are from MBNQA winners, however, are not realized for all companies involved in the MBNQA program, and it is important to set reasonable expectations especially with timelines for implementation and results to follow. In many cases, expectations of financial returns from administering quality programs and following MBNQA criteria are unreasonably high. In fact, *Davis* (2005) found that managers expected impractically low implementation cost and lofty returns—reporting expected improvements of 12% return on investment, 6.5% return on assets, 14% profits, and 15% customer satisfaction. When unrealistic expectations are set, the programs often cannot deliver and are deemed unsuccessful (*Hendricks and Singhal*, 1999).

Therefore, quality programs and MBNQA should not be seen as a "panacea for business, but rather a means with which to build and maintain a strong competitive foundation" and should not be expected to provide instant results (*Hendricks and Singhal*, 1999; *Zari, et al*., 1994). At the same time, many companies have demonstrated dramatically improved financial returns while pursuing the MBNQA and, hence, improving profit remains a top justification for involvement with MBNQA (*Davis*, 2005).

Perhaps the best-known study on the financial results of the MBNQA is the 'Baldrige Index.' In this annual study, $1,000 is placed in a fictitious stock fund of publicly traded MBNQA winners and compared to $1,000 hypothetically invested in the S&P 500 index. Between 1992 and 2002, the Baldrige Index outperformed the S&P 500 by 6.5 to 1 (NIST, 2003).

Another study compared 17 MBNQA winners between 1988 and 1996 to the S&P 500 index while adjusting for risk, market conditions such as inflation and interest rates, and variability unique to individual stocks such as labor strikes and lawsuits. In this study, MBNQA winners consistently outperformed the S&P 500 stocks having similar risk (*Tai and Przasnyski*, 1999).

Another fictitious stock index, the Q100, was created to track the quality leaders of the S&P 500. Between September 1998 and December 2001, the Q100, which was weighted and diversified to align with the S&P 500, experienced a return of 27% while the S&P 500 return was 17.6% during the same

time period. It was concluded that "in both bull and bear markets, quality improvement efforts have a direct and measurable impact on performance" (*George*, 2002).

Wisner and Eakins (1994) studied 17 MBNQA winners between 1988 and 1992 and found impressive achievements in customer service cost, production costs, product reliability, defect rate and cycle time reduction. During this time, companies increased sales by 75%, employee job satisfaction by 57%, and return on assets by 50%. Detailed analysis of financial performance (including annual sales, 5-year growth, return on sales, return on assets, return on net worth, P/E ratio, earnings per share, and 5-year average growth in earnings per share) on four of the companies calculated an increase of 58% in overall financial performance during the 4-year study period.

Ramasesh (1998) examined 13 publicly traded MBNQA winners between 1988 and 1996 and used S&P 500 index and the Wall Street Journal Index to track key performance metrics. Compared with the two indices, this study found significantly higher returns for the MBNQA winners, especially in regard to net sales per employee and reduction in inventories.

Jacob et al. (2004) compared 18, publicly-traded MBNQA winners between 1988 and 2002 to a benchmark group of 18 comparable (by SIC code and sales revenue) companies. Researchers compared several accounting metrics including a market-to-book ratio (market value of assets to the book value of assets), P/E ratio, and excess value ratio. Under uni-variate and multivariate tests, MBNQA winners performed significantly better than the industry medians in terms of profitability and asset utilization while having more leveraged debt and spending more on capital, R&D, and advertising. In short, winners were more valuable than the benchmark group and valued more highly by investors.

Wrolstad and Krueger (2001) compared 25 state quality award winning companies from 1988 to 1996 to companies matched by size and SIC code. Average changes for key metrics over the four year period are shown in Table 1.

Table 1. Changes in key indicators in 8-year study period (*Wrolstad and Krueger*, 2001)

	MBNQA Winners 1988-96	Matched, Non-Winning Companies, 1988-1996
Return on equity	+18.73%	-5.91%
Return on assets	+10.28%	-5.5%
Operating profit margin	+46.77%	+2.69%
Operating margin	+1.12	-1.71
Return on investment	+18.1%	+16.2% (S&P 500 Index, +13%)

Hendricks and Singhal (1999) studied 600 winners of different awards, including the MBNQA, state quality awards, and others created by large companies based on the MBNQA. All subject companies were publicly traded, allowing financial data to be obtained for the four years prior to the award (implementation period) to six years after winning (post implementation). The award winning companies' performance was compared to benchmark companies selected from the same industry and having similar asset value. During the implementation period, researchers found no significant differences in any performance criteria between the winners and non-winners. Post implementation, researchers found the following indicators:

Table 2. Performance indicators after winning quality award

Indicator	Quality Award Winners	Benchmark Companies (non-participants)
Growth in operating income	91%	43%
Sales increase	69%	32%
Total asset increase	79%	37%
Return on sales increase	8%	None

Many believe that, of quality-award winning firms, larger companies have an advantage. However, the researchers showed that small companies outperformed benchmarks by 63% on average, compared to 22% for large companies. The study also concluded that winners of independent awards (MBNQA and state awards) outperform winners of supplier awards. On average, independent award winners outperformed benchmark companies by 73% while supplier award winners outperformed benchmarks by 33%.

Other examples of high performance as a result of the use of the MBNQA criteria include the following. This data has been obtained from summary award application documents and profiles from MBNQA winners on the MBNQA website.
http://www.baldrige.nist.gov/Contacts_Profiles.htm

Small Businesses	Service Businesses	Manufacturing
MESA Products Inc • 93% increase in sales • 20% increase return on equity	Premier Inc • 90% Customer satisfaction • 15% increase in operating margin	Motorola Inc • 32% increase employee productivity • 99% customer satisfaction
PRO TEC • 2% employee turnover • 0.12% defect rate	Ritz Carlton • 99% guest satisfaction, 80% extremely satisfied • Pre tax return on investment and earnings doubled	Sunny Fresh Foods • 93% revenue increase • Market share increased while competition decreased by 10%
Texas Name Plate Co • Profit increase from 36% in 1998 to 40% in 2004	DynMcDermott Petroleum Operations • Customer satisfaction increased from 67% in 1999 to 74% in 2004	Boeing's Airlift and Tanker Program • Avoided loss of 10,000 jobs • 60% productivity increase

When used effectively, the MBNQA and other quality programs improve financial and non-financial performance. But, like any other aspect of business, there is no silver bullet. Instead, a company must apply knowledge, use judgment, clarify appropriate expectations, evaluate consequences, and monitor processes continuously. This is the case whether an organization plans to apply for the MBNQA or

simply to use its self-assessment process (Hardie, 1998, Hendricks and Singhal, 1999, Davis, 2005). However, Garvin (1991) may have stated it best, "While MBNQA winners are as vulnerable to economic downturns, shifts in fashion and technology, and other environmental impacts, they are better positioned than others to recover gracefully because they have superior management processes in place."

Quality in the Construction Industry

The next step is looking and quality management specifically in the construction industry. As quality management processes including Total Quality Management, Quality Assurance, ISO 9001, Six Sigma, and Lean continue to expand globally in manufacturing and other industries, these techniques have seeped into the construction industry (*Dahlgaard and Dahlgaard-Park*, 2006; *Aberdeen Group*, 2005; *Salem et. al*, 2005; *Abdul-Rashid & Abdul-Aziz*, 2002; *Mathews, et al.,* 2000). Quality has been adopted in the construction industry mainly because, as in any other industry, "it is critical that client satisfaction is achieved if an organization is to succeed, or indeed survive," (*Barratt*, 2000).

Due to the construction industry's uniquely complex and personal nature, understanding and meeting client requirements is key to success. Quality management processes in the construction industry have improved product quality and customer satisfaction, and reduced costs and employee injuries (*Hoonakker*, 2006). While many in the industry are attempting to improve quality, progress has been slow and fragmented (*Low and Hong*, 2005, *Haupt and Whiteman*, 2003). Further complicating the integration of quality processes is the unique aspects of the industry as *Low and Tan* (1996) point out, "the construction industry is characterized by activities which are discontinuous, dispersed, diverse and distinct in nature." Yet, the successful application of quality management in the industry is proven (*Bayfield and Roberts*, 2005).

Another unique aspect to new home construction is the use of trade contractors. Where quality methods are employed in the industry, the principles are often applied only at the management level and not successfully transferred into field operations (*Haupt and Whiteman*, 2003). The issue is complicated by the industry's use of trade contractors, which undertake 90% to 100% of job site construction (*Abdul-Rashid and Abdul-Aziz*, 2002). No doubt, client satisfaction and contractor performance are "positively and strongly associated with their relationships with sub-contractors," (*Xiao and Proverbs*, 2003). Therefore, the best way to improve relationships and quality with trade contractors is to focus on building partnerships (*Mathews, et al.,* 2000) which involves collaborating on resource efficiency, financial issues, and combined goals (*Bayfield and Roberts*, 2005). Barratt (2000) concludes that a combination of "sound formal systems and strong relationships is essential to achieve high quality in the project environment of construction."

According to *Xiao and Proverbs* (2002), "quality tends to suffer from attitudinal rather than technological problems; there is a need to create a culture of quality." Creating this culture requires behavioral changes and, therefore, commitment from company leaders may be the primary factor for successful implementation, (*Salem, et. al*, 2005). It is only a mind shift by senior management that will lead to the industry fully embracing quality management (*Low and Hong*, 2005; *Haupt and Whiteman*, 2003). Yet, to be successful, the programs must be pervasive not just among managers, but also throughout the company and in the field.

The Impact of Quality for Home Building Companies

So what impacts are possible if quality management is applied to homebuilding? A 2008 study by *Professional Builder* magazine ranked the issues that its "Giants" of homebuilding report as the greatest opportunities for home building companies. At the top of this list was operational efficiency and third ranked was better product and services. Both of these top-ranked improvement opportunities can be addressed using quality tools and techniques (see Figure 6).

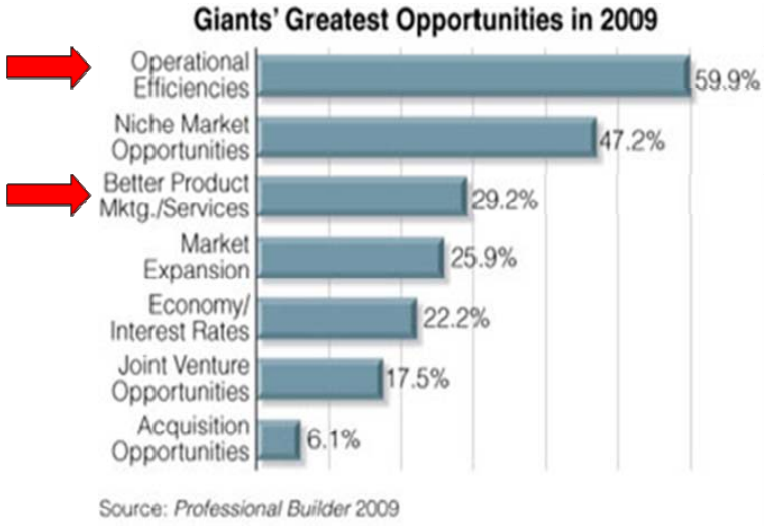
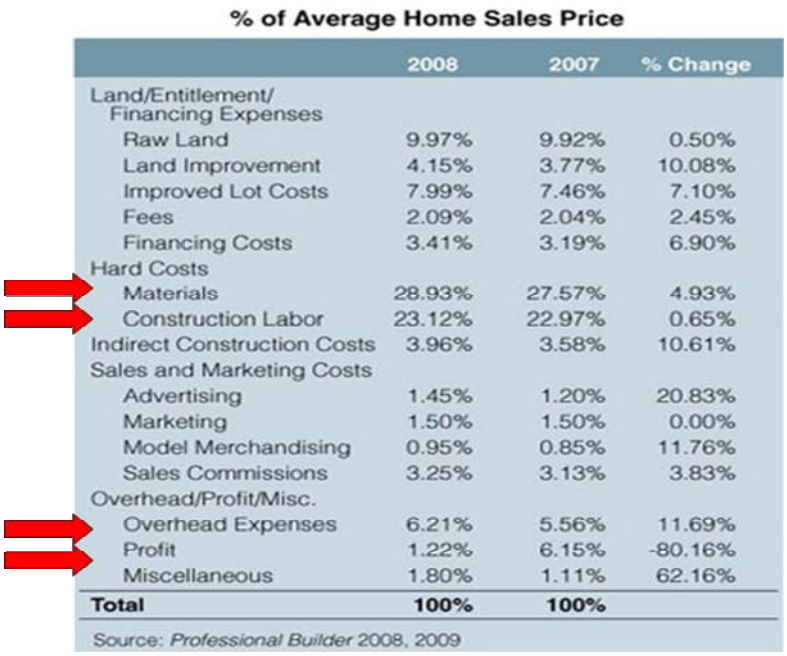


Figure 6. Opportunities for builders (*Professional Builder* Magazine, May 2009)

Considering the potential for operational efficiencies outlined in the economics of quality section, and profits from Figure 7, it becomes apparent that substantial financial impacts can be made by implementing a quality program. Using 2008 data from Figure 7 with *Rodchua's* (2002) average numbers for the cost of quality, 3.5% of revenue is cost of quality and of that 75% of cost of quality is failure costs. Therefore 2.62% of revenue is failure cost.



% of Average Home Sales Price

	2008	2007	% Change
Land/Entitlement/ Financing Expenses			
Raw Land	9.97%	9.92%	0.50%
Land Improvement	4.15%	3.77%	10.08%
Improved Lot Costs	7.99%	7.46%	7.10%
Fees	2.09%	2.04%	2.45%
Financing Costs	3.41%	3.19%	6.90%
Hard Costs			
Materials	28.93%	27.57%	4.93%
Construction Labor	23.12%	22.97%	0.65%
Indirect Construction Costs	3.96%	3.58%	10.61%
Sales and Marketing Costs			
Advertising	1.45%	1.20%	20.83%
Marketing	1.50%	1.50%	0.00%
Model Merchandising	0.95%	0.85%	11.76%
Sales Commissions	3.25%	3.13%	3.83%
Overhead/Profit/Misc.			
Overhead Expenses	6.21%	5.56%	11.69%
Profit	1.22%	6.15%	-80.16%
Miscellaneous	1.80%	1.11%	62.16%
Total	**100%**	**100%**	

Source: *Professional Builder* 2008, 2009

Figure 7. Component costs of the average home sales price (*Professional Builder* magazine, May 2009)

For example, if a builder constructs 50 homes per year which sell for $150,000 each:

At 2.62% of revenue being failure cost:
2.62% x $150,000 = $3,930 failure cost/house

At 1.22% profit per house:
1.22% x $150,000 = $1,830 profit/house

Therefore for 50 homes per year, failure cost per year:
50 x $3,930 = $196,500 failure cost/yr
The equivalent of 1 home per year is the failure cost/yr

A 2006 study of nearly 32,000 homes by Quality Built supports these levels of failure costs. The study revealed the average cost to correct defects in new single-family homes was $5,400 and more than $4,500 for multifamily and light commercial construction (Quality Built, 2006).

The potential positive impact of quality improvement was illustrated by JD Power study (JD Power, 2006). An average JD Power builder with a JD Power index score of 112 receives 3.96 positive recommendations per homebuyer. At an index score of 122, the same builder would receive 4.62 positive recommendations per homebuyer. This increase in recommendations, using JD Power's customer-based data for return rates, average sales price, and other indicators, would ultimately translate to $175,000 increased profit.

0.66 Additional Recommendation per Buyer	X	***128*** Average Number of Returned Questionnaires per Builder	=	***84*** Potential Customers	X	15% Convert to Sales	=	***12*** Additional Home Sales

X $292,000 Average Sale Price
= $3,504,000 Revenue
X 5% Average Profit Margin
$175,000
= **Additional Profit from additional recommendations**

Figure 8. JD Power example of increased profits due to increased customer satisfaction.

In another study by the Department of Energy on a modular home building company showed a 59% gain in labor productivity and a simultaneous 22% cycle time reduction due to the implementation of a quality management program (U.S. DOE, 2005).

The NAHB Research Center's National Housing Quality (NHQ) program has also shown the impact of quality implementation with traditional residential home builders. A 2007 survey by the NAHB Research Center's National Housing Quality (NHQ) program builders revealed that, after achieving NHQ certification:

- 80% of NHQ certified trade contractors reported a reduction in callbacks
- 88% achieved an increase in employee accountability
- 79% improved relationships with builders
- 65% overall improved their bottom line
- 70% of NHQ certified builders improved their bottom line
- 75 % reported a reduction in callbacks and improved relationships with trades
- Up to 25% reduction in cycle time for certified trade contractors (NAHBRC, 2007)

National Housing Quality Award (NHQA) winning builders have noted tremendous impacts from implementing quality management systems. A sampling of results includes:

- 98% homes zero defects at closing, net profit increased 9% (Grayson Homes, MD)
- Reduced cycle time by 15% (Pringle Homes, FL)
- 95% of trades list builder as the best to work for (Estes Homes, WA)
- 33% of homeowner recommendations resulting in sale (TS Lewis, AZ).
- (Professional Builder Magazine, 2009)

Finally, and perhaps most compellingly, a 1997 NAHB study reported the average builder net income before taxes of 5.1% and gross margin of 18.5%; NHQA builders, on the other hand, achieved an average net income of 11.2% and gross margin of 25.5%. (NAHB, 1997)

Business Results of Implementing Quality Management

Builders that have successfully implemented quality management reap excellent rewards in profitability, product quality, customer satisfaction, and employee satisfaction. Between 1993 and 2009, National Housing Quality Award-winning builders report the following impacts and performance indicators, many of which are a direct result of implementing effective quality management:

Category	NHQA Winning Builder Benefit from Quality
Profits (Gross Margins)	12-20%
Revenue	15-100% increase/yr
Construction Costs vs. Budget	+/- 1%
Customer Satisfaction	93-97%
Referral Rates (Sales made through referral)	29%
Cycle Time Reductions	15-50%
Zero Defects at Closing	98%
Defect Reductions	11-75%
Employee Satisfaction	94%
Trade Satisfaction	95%
Customer Endorsements/ Thank You Letters	73%
Warranty Requests	1 per every 15.5 homes

Winners of the National Housing Quality Award do not adhere to quality management to win awards. Instead, they cite cost savings, reduced defects, job satisfaction, customer satisfaction, and profitability as the motivation for quality management. As an example, the following are quotes from NHQ award-winning builders and *Professional Builder* magazine regarding the value of quality.

> "**Quality and satisfaction save money.** You save a lot of money getting it right the first time. Make one trip [to the site], and you don't have to go back." –K. Hovnanian Virginia, *2009 NHQ silver award winner*
>
> "About 400 to 500 Opportunities for Improvement are suggested a year and about 80 percent of them are implemented, **saving thousands of dollars and improving the customer experience**." –Wayne Homes*, 2010 NHQ silver award winner*
>
> ""Our most recent 'Cost Walk' generated over 500 ideas for improvement. Many of them were implemented, and **we documented savings of over $150,000 a year**." –Pringle Development, *2008 NHQ silver award winner*
>
> **It's also about getting the performance that you measure**. We started posting the trade contractors' relative performance and letting them all see where they stood. It seemed to really spur them on to greater things." –Pringle Development, *2008 NHQ silver award winner*
>
> Kevin Egan, president and COO, "**The reason we've been successful** is it starts with our mission and our vision, **We're disciplined in our processes and operations, setting goals and objectives and tracking key performance indicators and communicating that information." –**TW Lewis, *2009 NHQ gold award winner*

"We decided that **we wanted to start having fun. We wanted to make money. And we wanted a good name.** That is when we started to turn things around." –Don Simon Homes, *2002 NHQ gold award winner*

From "**maximizing customer satisfaction with final product and overall building experience"** to **"designing, integrating and aligning all business functions to maximize efficiency and profits throughout the organization**," these success drivers are the genesis of the company's strategic plan. –Don Simon Homes, *2001 NHQ silver award winner*

"We don't build a single home. We are managers. We create schedules. We obtain the materials, locations, plans, et cetera, but we don't build a thing. We deal with contractors, many of whom have been in business a long time. They have experience that we don't." –Pulte Homes Minnesota, *2003 NHQ silver award winner*

Quality leadership is like that. It's not passed down, layer by layer, until the folks that do the work "understand. **Quality leadership rises to the top. Common values become company values, and company values become a culture that nurtures success." –**Winans Construction, *2001 NHQ gold award winner*

"Any company that embarks upon the NHQ process constantly seeks improvement. For us, that meant growing not necessarily in volume but in ways that would actually accomplish something for us, **make us more efficient and create more opportunities for my employees.**" –Boardwalk Builders, *2004 NHQ silver award winner*

"We felt that we really needed to have **good communication with our customer**, which mostly means no surprises. We have checklists and systems in place [to ensure] this happens with every single customer in every single home. **I see a lot of companies winging everything, including the repetitive-type tasks, and I see that as a huge waste of time and resources." –**Estes Builders, *2005 NHQ silver award winner*

"We have certain **success drivers: business profitability, customer loyalty, operating efficiency and employee department loyalty.** Every other week, everyone in the organization comes together --all 140 of us. We start every meeting with our vision or mission. **It's how you communicate effectively with your team about what's important.** You need to be part of that process." Veridian Homes, *2005 NHQ silver award winner*

"Efficiency and profitability drive decisions. A mindset to constantly improve processes and procedures helps the company overcome any obstacles. The company strives to clearly communicate its goals and objectives to employees to make sure they're aware of changes to the company's strategic plan." As one of the first contractors in the nation to achieve NHQ Certified Framing Trade Contractor status, the company recognizes the need to **minimize risk associated with construction defect litigation and rising insurance premiums**." – Schuck & Sons, *2007 NHQ silver award winner*

"Partnerships with trade contractors and suppliers are an industry best practice with systematic integration addressing the goals and objectives of the organization." Shea Homes, *2006 NHQ gold award winner*

"When times are tough—and no one is immune to our economy's downfall—it's easy to forgo routines and strategy critical to business success. But Siminoni Builders **maintained its business**

rhythm and devotion to employees as the challenges mounted." – Simonini Builders, *2010 NHQ gold award winner*

"Performance and progress are closely monitored with daily "dashboard" reports and monthly "scorecards." **Color coded scorecards allow managers to be quickly alerted to problem spots so changes can be made to address any deficiencies or variances from the established business plans." –**Fireside Hearth & Home, *2008 NHQ Silver Award winner*

These references show the dramatic positive impacts that quality management can provide on a wide range of performance indicators including ultimately, profitability.

The Impact of High Performing Homes

Beyond implementing quality management in general, as well as specifically in homes, adding the goal of high performance homes can also lead to improved customer satisfaction. A 2007 NAHB survey revealed that home buyers want energy efficient, low-maintenance, well-insulated and well-sealed homes and they are willing to pay a premium for them (Figures 9 & 10). Indeed, homeowners are not simply attracted to high performing homes; they are more satisfied with these homes. According to McGraw-Hill (2007), 63% of green home buyers are attracted to high performing homes due to lower operating and maintenance costs. Yet, 85% reported being more satisfied with their new green homes than with their previous, traditionally-built homes. By coupling quality management systems with high performance home building techniques, builders are likely to create satisfied customers and, hence, increased profit.

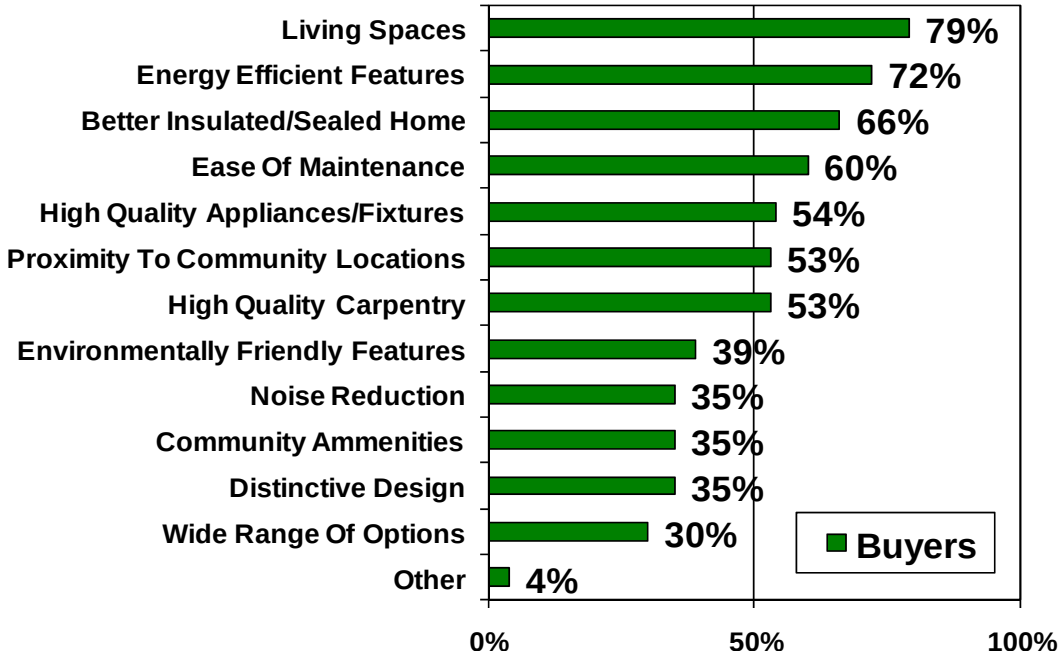


Figure 9. What homeowners want (NAHB, 2007)

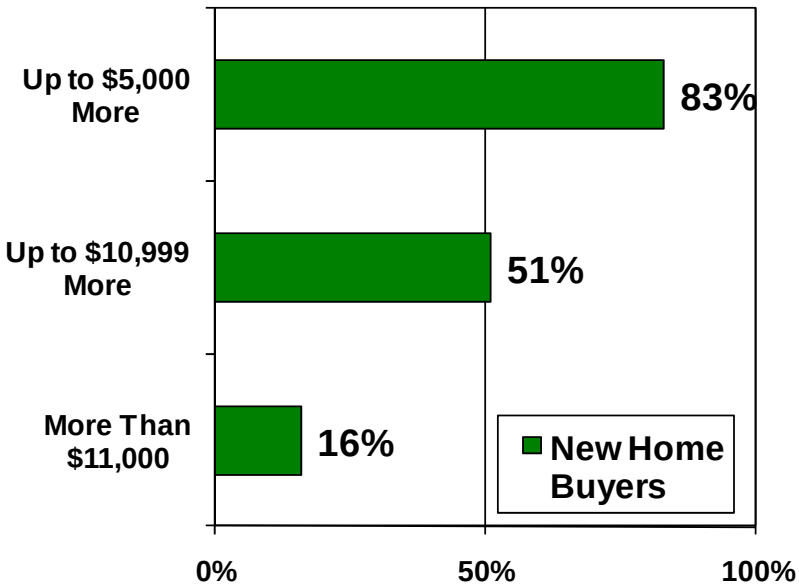


Figure 10. What homeowners are willing to pay for the energy efficient features they want in homes (NAHB, 2007)

Quality Management Tools & Techniques

The motivation for quality management for high performance homes makes sense based on value, costs, revenue, and customer service. In addition, quality management has the most impact when strategically coordinated, driven and aligned throughout the organization. From the strategic level, coordination flows through a tactical and then operational level. (Figure 11)

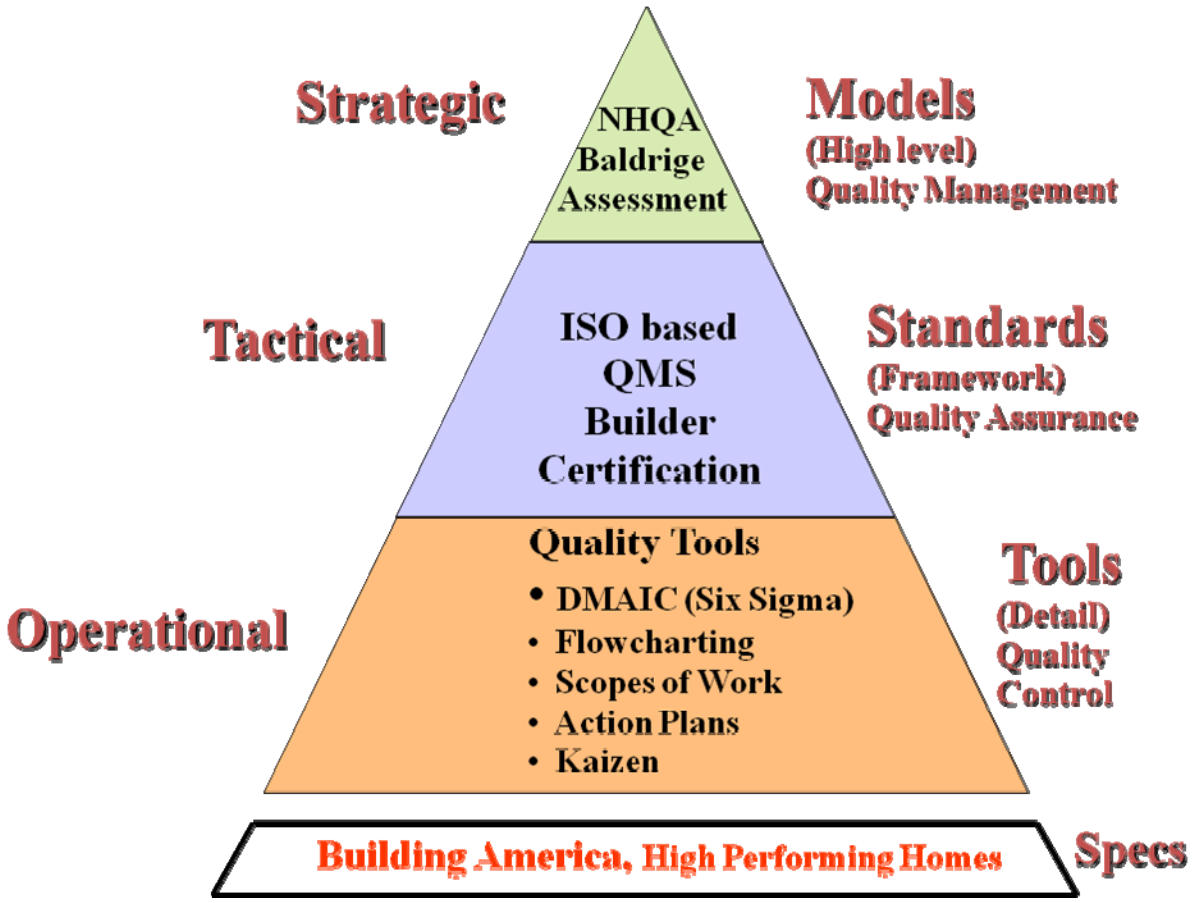


Figure 11. Strategic, tactical and operational layering of quality management.

Strategic Models

As the strategic level, the NHQA application process helps builders self-assess their quality management program, identify gaps, and coordinate improvement of factors critical to business success. The NHQA Criteria for Performance Excellence has served as an important tool for hundreds of home builders and trade contractors. The criteria help to:

- Align resources
- Improve communication
- Increase productivity
- Boost effectiveness
- Achieve strategic goals

The NHQA Criteria for Performance Excellence includes the following categories:

1. Leadership
   How do your company's senior leaders guide the organization toward a common purpose based on shared values and priorities?
2. Strategic Planning

How do you create and implement a strategic plan to achieve a vision for the future, enhance your competitive position, and improve overall performance?

3. Performance Management
   How are your company's business processes developed, managed, measured, and improved to achieve performance excellence?
4. Customer Satisfaction
   How does your company manage the design and delivery of products and services that promise a high level of customer satisfaction?
5. Human Resources
   How do your employee selection and development practices, as well as staff performance management, well-being, motivation, satisfaction, and compensation contribute to the growth of your organization?
6. Construction Quality
   What methods does your company use to drive quality in the home construction process and ensure high performing, trouble free products and services?
7. Trade Partnerships
   How do you create high performance relationship with your independent trade partners?
8. Business Results
   What are the tangible measurements of the business benefits resulting from your high performance practices in the financial, operational, customer satisfaction, and product and service quality areas?

Using the criteria, self-assessment can identify strengths and target opportunities for improvement that impact customers, employees, owners, suppliers, and the public. The NHQ self-assessment process is not only a first step toward driving improvement throughout an organization, but also toward submitting an application for the NHQA award process annually. Writing an application, in fact, is in itself a method of self-assessment.

When an award application is submitted, it undergoes review by a team of expert judges. Finalists further receive a site visit by a judging team that may last several days. In either case, applicants receive detailed, actionable feedback reports to support continued improvement.

The NHQA process is an ideal strategic tool for organizations. It helps companies learn quality concepts, begin self-assessment, implement improvement, submit an application, and gain valuable independent feedback for improvement.

Tactical Standards

The NAHB Research Center's NHQ Certified Builder and NHQ Certified Trade Contractor programs can represent tactical quality management systems (QMS) for the construction industry. These programs based on ISO 9000, ISO 14000, and OSHA 18000 focus on driving quality assurance through a QMS. These programs set criteria for quality, safety, and environmental management in the homebuilding industry.

Both certification programs, which involve annual third-party audits, incorporate the critical issues of continual improvement and corrective and preventive with a unique focus on homebuilding industry issues. Companies that go through the process of certification must demonstrate quality management

systems throughout the company—from scheduling work and creating jobsite inspection lists to ensuring job ready conditions and partnering with trades on quality initiatives.

In fact, NHQ certified builders are strongly encouraging trade partners to seek NHQ certification, since contractors provide nearly all of the skilled labor used to construct homes. Some NHQ certified builders pay for over 12 hours of training and support the development of quality manuals required for certification. The emphasis has been to ensure that a complete chain of quality processes is achieved with all partners.

During the NHQ certification process, builders and trade contractors must develop a quality manual and set of procedures that cover the following encompassing areas:

General
- Scope
- Leadership
- Quality statements
- Quality manual
- Responsibilities
- Organizational chart
- Training
- Performance management
- Process flow

Management System
- Committee
- Audits
- Annual reviews
- Changes
- Document control
- Records
- Reference documents

Procedures
- Scopes
- Procedures
- Codes
- Standards
- Manufacturers' instructions
- Contracts
- Schedules
- Approval of trades
- Control of specifications and plans
- Job ready, in process and complete inspection
- Corrective and preventive action
- Training

Operational

Operational tools are those that make improvements happen. The NAHB Research Center has developed many tools, specific to the home building industry, to support quality improvement. These and other quality specific tools include:

- Scopes of Work
- Procedure Documents
- Checklists
- Six Sigma DMAIC process
- Process Mapping
- Value stream mapping
- Failure mode effects analysis (FMEA)
- 5S
- 8D

- Fishbone Charts
- 80/20 rule
- Brainstorming

One additional measure that the NAHB Research Center plans to address in future quality management work includes the design of high performance homes. To date, existing quality management programs have not addressed the need to design the house as a system which is vital in high performance homes.

Suggested Cost of Quality Metrics for Home Builders

Although the value for quality management was detailed above, in order for a builder to be able to quantify quality, it is necessary to have standard metrics and methodologies for measuring quality management. For the home building industry, cost of quality metrics for high performance homes should ideally follow the Prevention, Appraisal and Failure model. By measuring these metrics a homebuilder can establish their current levels of performance and then monitor year on year their performance, measure improvement and benchmark themselves against the best in the industry.

Quality performance metrics

There are many performance metrics to measure the success of a quality management system including scheduling, costs, etc. These are detailed further below.

Schedule

- *Construction Schedules* - (ideally this is in working days) This metric allows a builder to ensure 'on time' construction by milestone as well as firm timelines to focus on for improvement i.e. reducing cycle times. Some of the suggested categories are included below. However, the intent is that these are customized and each builder uses them to provide as much detail as possible to determine if the schedules are met or not.
    - Design
    - Contract signing to closing
    - Contract signing to excavation
    - Excavation foundation
    - Excavation back fill
    - Weather days
    - Framing
    - Frame start to certificate of occupancy
    - Rough mechanical
    - Drywall
    - Trim
    - Pre-punch to closing
    - Testing
    - Inspections
- *Milestones* - This metric includes the date of the milestones to further detail the construction schedule above.
- *On Time Delivery* - To track this metric, a builder has to first determine when the when the builder considers the delivery to the customer (such as closing). Once this is defined, and based on the construction schedule, the on time delivery can be reported as a simple yes or no. Beyond this, a builder can then relate the on time delivery as a percentage of projects completed.

Energy Performance

- *Air Infiltration Testing* - This metric is the result of the blower door test to measure the air infiltration (leakage) of the home to the exterior.
- *Duct Leakage Testing* - This metric is the result of the duct blaster test to measure the leakage of the duct system to the exterior and the interior to determine heat loss and delivery efficiency of the duct system.
- *BA Benchmark/HERS Index* - This metric uses energy simulations, the air infiltration, and duct leakage measurements to estimate the energy use and costs of the home.

Costs

- *Profits* - This metric details the profits for the project including:
  - Gross Profit= net sales - cost of goods sold
  - Net Profit= gross profit - Total operating expenses
- *Inspection Costs* - This metric details all costs involved in checking and rechecking someone else's work (that they should have checked and done right the first time) this will include, labor, truck, fuel costs etc.
- *Verification Costs* - This metric details the costs to verify the performance of the home including the air infiltration testing, duct leakage testing, and any program verifications such as Builders Challenge, ENERGY STAR, green programs, etc.
- *Warranty Costs* - This metric can cover all costs including labor, fuel, trucks, material and time for rework and repair for customer call backs. In addition, it can also include litigation and insurance costs.

Training

- *Training Costs* - this would include all training courses, books and other materials and may include overhead for internal management time for training and even time taken from work to attend certain all company meetings.

Satisfaction - Customer, Employee, Trade, Etc.

- *Customer Satisfaction* - (challenges discussed following) This metric is a score reflecting for detailed aspects of the construction process and/or for the overall satisfaction of the client with the process and finished product. The higher the score the better the chance of referrals and return work in the future.
- *Warranty Customer Satisfaction Rating* - This metric can be a detailed customer satisfaction score or sub-score (from other questions) that allows a builder to focus on sub sections of their after construction/warranty process and key individuals in that process. This helps focus on specific areas of improvement.
- *Construction Manager Customer Satisfaction Rating* – This metric can be a detailed customer satisfaction score or sub-score (from other questions) that allows a builder to focus on sub sections of their construction process and key individuals in that process. This helps focus on specific areas of improvement.
- *Trade/Supplier Satisfaction* - This metric provides insights into the satisfaction of a builder's trades and/or suppliers. Finding potential new trade partners, evaluating them, training them to meet the builder's schedules, scopes of work, etc is time consuming and expensive. A builder wants to keep their well trained, experienced trade partners. A trade/supplier satisfaction survey allows a builder to uncover dissatisfaction they may have which they can address while also allowing them to suggested areas to improve that may save time or money on the job. Again there are various rating systems, survey approaches, and time

periods for conducting trade/supplier satisfaction surveys and so its challenges are also very similar to that of customer satisfaction discussed earlier.

- *Employee Satisfaction* - This metric provides insights to the morale and culture of an organization and is focused on reducing the rate of employee turnover by gaining feedback on how the builder can make the work-life of their employees better. Hiring and training new employees is very expensive, ensuring a builder keeps their trained, experienced existing employees is a good investment. There are various rating systems, survey approaches and time periods for conducting employee satisfaction surveys and so its challenges are very similar to that of customer satisfaction discussed earlier.

Referral

- *Referral Rates* - This metric details the percentage of customers that actually did refer someone to a builder's business.

Productivity

- *Sales per Employee* - This metric is gross sales/revenue divided by the number of employees and provides an insight to how productive a builder is as an organization.
- *Units /projects per Employee/Trade* - This metric is another measure of how productivity.

Warranty/Defects

- *Number of Warranty Calls* - This metric can be measured as call backs per customer /home sold. Obviously the less of these the better. The fewer the higher the customer satisfaction and the higher the referral rates and of course the lower the unnecessary costs incurred by a builder which reduce their profit margins. This will reduce their customer satisfaction scores, chances for referrals and potentially result in the customer unfortunately promoting how bad their business is to other potential customers.
- *Time to Complete Warranty Calls* - This metric is measured in days from the day the customer called until the work is completed. If the customer calls back later on this same issue i.e. the issue was not adequately resolved then it gets added on to the original issue length in days. This reflects how well they respond and correct issues first time. The longer it takes to complete warranty issues will result in reduced customer satisfaction scores, chances for referrals and potentially result in the customer unfortunately promoting how bad business is to other potential customers.
- *Walk Through Pre Punch Defects* - This metric is the number of defects found by the inspector or superintendent on a final walk through of their home. This would be defects per square foot of home. The more defects found, the more rework needs to be done. This is unnecessary (it was not done correctly first time even though you paid for it) and further reduces your profit margin.
- *Customer Walk Through Defects* - This metric is the number of defects found by the customer on a final walk through of their home. This would be defects per square foot of home. This will reduce your customer satisfaction score and also the possibility of referrals.

One issue with the metrics is that looking at metrics across multiple builders can be difficult. A key challenge that needs to be recognized and addressed is that every builder uses different metrics to monitor its operations. To look at multiple builders, the metrics need to be standardized so that there is an agreed set of 'master metrics' which builders would ideally use or which would be used to 'convert' various builder metric formats. This would ensure that all data would be presented in one consistent and coherent manner to compare 'apples to apples'.

Examples of challenges due to the range of ways in which different organizations collect their data include:

Challenges: Cost

- Warranty costs as a % of gross sales/revenue
- Warranty costs $ per home
- Warranty costs $ per year per home sold

In addition, some include staff costs and some do not.

Challenges: Customer Satisfaction

- 3rd party customer satisfaction survey companies
- Their own internal surveys
- Customers surveyed after move in / completion of project after
  - 30 days,
  - 45 days,
  - 11 months,
  - 12 months, and/or
  - 18 months
- Rating scales for surveys
  - Range 1-6,
  - Range 1-5, or
  - Range 1-10
- Satisfaction
  - Recommendations to a friend or family member
  - Direct question about satisfaction
  - Sub survey answers to create a combined satisfaction score

Customer satisfaction can also be survey and measured for key steps and by department i.e. construction manager/supervisor or warranty for example.

Challenges: Defects

- Square foot per defect
- Defect per square foot
- Defect per room
- Defect count per home (regardless of square footage per home)

In addition, some count every paint scratch others paint defects on a per room basis

Challenges: Other issues

Similar problems relate to employee satisfaction and supplier/partner/sub-contractor surveys. Problems also arise with production or even cycle time measures for example some use working days others use days (that include weekends).

Start and finish of project also creates problems for example some start the project cycle times based on contract signing, arrival on site, work starting and finishing times as work completed by contractor or sign off by home owner or certificate of occupancy.

Conclusion

The value of quality management can have an impact on the economics of quality management. Determining the costs of quality allow a high performance home builder to optimize their costs through optimizing the prevention of defects through appraisals and the number of failures. In addition, there is a direct connection between quality management and increased customer satisfaction. Numerous manufacturers, builders, high performance home builders, Malcolm Baldrige National Quality Award winners, National Housing Quality Award (NHQA) winners have documented value of quality management, cost savings, increased customer satisfaction, and other benefits of implementing quality management systems. To help builders implement quality management, there are many tools available including the NHQA application process.

One necessary step to quantifying quality is measuring the success of quality management. It is important to document schedules, energy performance, costs, training, satisfaction, referrals, productivity, and warranty/defects. Consistently measuring these metrics will allow a builder to determine where they are at and places for improvements. In addition, this will allow a larger study of the impact of quality including value, costs, energy and quality performance, customer satisfaction, and the impact in the construction industry. Those builders that have already adopted these practices have seen significant improvements in the performance of their businesses.

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Appendix B: Quality Management and High Performance Home Building: A Case Study of Veridian Homes

Introduction

The cost and energy savings from high performance homes can be quantified through energy simulations in conjunction with testing and monitoring. Similarly, the value of a quality management system can be quantified in new home construction through quality performance metrics. These metrics include schedules, energy performance, costs, training, satisfaction, referrals, productivity, and warranty/defects as outlined in the NAHB Research Center's Economics of Quality Report[1]. There are currently builders constructing high performance homes that have already implemented quality management systems. The goal of this interim report is to detail a builder, Veridian Homes that has already implemented a quality management system and is monitoring the impact of quality and energy efficiency.

Impacting Business Results

Veridian Homes of Madison, Wisconsin, is a shining example of how quality management and high performance home building techniques can impact a company's success. Veridian Homes, formed in 2003 out of two longstanding, family-owned companies—Don Simon Homes (founded in 1956) and Midland Builders (founded in 1953)—has created the following core business results:

- Profits above average of its Builder 20 Club
- Construction budget versus actual construction costs -/+1%
- 95% + customer satisfaction
- 76% of Veridian Home buyers did not consider another builder
- 90% of its homes at home orientation at zero defects
- HERS Index on production homes of 58-61 (39% to 42% better than the IECC)

Veridian Homes achieves these bottom-line numbers by focusing on the following:

An even flow production schedule which achieves:

- 2.5 homes starts per day
- 550 homes per year capacity
- Closing date guaranteed at contract signing
- 100% on-time closing in more than five years
- 40 models each with multiple elevations and floor plans in addition to personal choices for finishes

While achieving:

- 100% homes Green Built Home certified and ENERGY STAR labeled
- Over 50% of construction waste recycled

[1] NAHB Research Center, The Economics of Quality, June 2010

Veridian Homes's even flow production schedule for light-framed homes on basement foundations is as follows:

Working Days

- Contract signing to closing 83
- Frame start to certificate of occupancy 45
  - Contract signing to dig 25
  - Excavation foundation 3
  - Excavation backfill 7
  - Weather days 3
  - Framing 8
  - Rough mechanical 3
  - Drywall 8
  - Trim 6
  - Pre-punch to closing 6

Besides building all of its homes to Green Built Home and ENERGY STAR program standards, Veridian Homes has built demonstration homes to gain experience and to examine new practices that is may adopt. To date, the company has built:

- More than 3000 ENERGY STAR Homes
- More than 3000 Green Built Homes
- Six LEED for Homes pilot projects
- Two Building America Zero Energy Prototype Homes

The company has also made improvements to its processes so that it can continue to achieve and improve upon the above program goals. These process improvements include:

- In a single year, reduced defects by 50% while cutting inspections in half
- Reduced warranty costs and defects between 30% and 75%
- Reduced construction cycle time by 18 days
- Shortened drafting time on model homes by more than one hour
- Cut estimating time on model homes by 32%
- Reduced material variance (difference between ordered and required quantities) for lumber by 20%, siding by 24%, and trim by 38%
- Reduced paperwork processing time by 208 hours per year by introducing a production scheduler software system, BuilderMT. The software resulted in an estimated $200,000 savings through performance increases.
- Reduced labor time for escrow and warranty processes by 10%.

Veridian Homes excellence has been recognized by third party organizations covering myriad disciplines including quality, safety, environmental, energy efficiency, design, estimating, construction, information technology, sales, marketing, social responsibility, customer satisfaction and leadership. Veridian Homes has been the recipient of many awards, including:

- 2010 Energy Value Housing Award (Production)

- 2009 Energy Star Leadership in Housing Award
- 2008 WasteCap Big (Waste) Diverter Award
- 2008 Energy Value Housing Award s (Production, Multi-family, and & Affordable)
- 2008 Builder of the Year, Professional Builder Magazine
- 2007 and 2008 Innovative Housing Technology Award
- 2007 and 2008 APEX Leadership Awards (Construction, Information Technology, Quality, Design & and Estimating)
- 2007 CIO Awards
- 2007 Energy Value Housing Award (Builder of the Year & Custom Home)
- 2007 SAFE Award (Safety Award for Excellence), NAHB
- 2006 and 2007 Energy Star ENERGY STAR Sustaining Partner Award
- 2006 WI Wisconsin Green Tier 1 & and Green Tier Clear Lakes Charter
- 2006 National Housing Quality Gold Award
- 2006 WasteCap Partner of the Year
- 2006 Governor's Environmental Award
- 2006 Waste Recycling Partnership Award
- 2006 Effie Award, National Award for Marketing Campaigns
- 2006 National Housing Endowment (NAHB) Bronze Builder Achievement Award for Outstanding Community Service
- 2005 Green Building Project of the Year Award, NAHB
- 2005 National Housing Quality Silver Award
- 2005 National Design Studio Award
- 2005 Wisconsin Governor's Award, for Wisconsin Production Home Builder of the Year
- 2004 and 2005 Energy Star Partner of the Year
- 2004 Certified Quality Builder, NAHB Research Center
- 2004 Executive Consumer Award for Favorite Residential Builder, by In Business Magazine
- 2004 Best Design Center, Gold Award, NAHB National Sales & and Marketing Council
- 2003 America's Best Builder Award (Don Simon Homes)

"Winning awards is not our objective," says David Simon, Veridian Homes's president of operations, "but they serve as reassurance that we, as a company, are headed in the right direction. We have a strong drive and desire to be the best in terms of what we can provide for our customers in better homes, better neighborhoods and a better environment. Our awards provide us with benchmarks that let us know how we are doing and how to drive improvement."

By using quality management and high performance homes as key business drivers, Veridian Homes has achieved enviable success.

Achieving a Long Term Highly Successful Home Building Business

Veridian Homes achieves consistently excellent operating metrics and bottom-line financials through the rigorous, systematic implementation of quality management and high performance home building practices across all aspects of the company. The company's success starts with its corporate culture, the core of which lies Veridian Homes's mission and values.

Vision and Mission

Veridian Homes's vision is to build great homes by never losing sight of what is important: customers, employees, communities, and the environment.

Values

To guide decisions and behavior, Veridian Homes has articulated 27 core values, divided into six key drivers: customer delight, innovative environments, unparalleled quality, lasting relationships, best practices, and community commitment.

Figure 1. Veridian Homes partners David Simon, president of operations, and Jeff Rosenberg, president of land development and acquisition

Leadership

Veridian Homes is focused on traditional community development based on smart growth principles and green building practices with an emphasis on process improvement. Although the home building industry is notoriously slow to adopt innovation, Veridian Homes has sought best practices and quality improvement methods from outside the industry and adapted them to its home building process.

What also makes Veridian Homes unique is its efforts to continuously improve manufacturing process efficiency. This includes rigorous attention to quality improvement, insistence on top-notch employee and trade partner ethics, and steadfast dedication to reducing the impact that its operations have on the environment.

With a market share of more than 30%, Veridian Homes is the largest residential builder in Wisconsin. Historically, it has constructed up to 500 single-family and attached homes and condominiums per year ranging in price from $170,000 to $700,000. Since the company was founded, its profitability has remained in the top 25% of the NAHB-sponsored Builder 20 groups nationwide. In 2009, the company had profits of $60 million.

Exceeding Customer Expectations

Veridian Homes maintains a portfolio of more than 40 plans, including single-family, twin-home, townhome, and condominium designs, and offers buyers virtually unlimited options for customization. This flexibility in price, style, and product line allows the builder to appeal to a broad spectrum of buyers ranging from first time buyers to empty nesters with a series of home plans that would typically be designed only for move-up or luxury buyers.

"We recognize that it takes a lot of effort for people to move," says Simon, "and the reality is that they are just not that willing to do it. So we do everything we can to make the process hassle-free."

The company makes a wide range of financing options and incentives available to buyers to simplify the purchase process, including a zero down payment program. Other programs include a guarantee of the sale of the buyer's existing home, rent liberation, and a discount for repeat buyers on the price of a new Veridian home.

"Our mission is to build great homes and great communities," says Simon. Company employees are guided by the principle that "setting expectations and over-delivering" is the best way to have a satisfied customer in the end.

"We look at our vision as one customer at a time, one home at a time. Our goal is to make each customer feel as though they are the most important person in our lives when we work with them," says Simon.

Translating that sentiment into practical application takes a keen awareness of today's buyer markets and a willingness to roll with the changes. "First and foremost, home builders have to recognize that our business is all about how we can fulfill our customers' dreams—how we can enrich their lives through the homes we build for them," says Simon, "but it is just as important to realize that every year, customer's expectations are going up. To be successful we have to be constantly reinventing ourselves to meet those evolving expectations and to keep pushing the bar in terms of customer satisfaction and quality.

"Our industry must continue to move forward. On the whole, builders have been slow to adapt to the changes in the marketplace. Yet, there exists a constant challenge to move beyond the status quo because other industries are doing it. Our customers are used to getting high levels of service elsewhere, and it just makes sense that they are going to expect it from us as well."

Even Flow Production

By streamlining its operations, Veridian Homes has been able to achieve an aggressive benchmark, starting 2.5 homes every working day in an even flow production schedule. The discipline of working to this even flow construction cycle and connecting all other aspects of the business to it is vital to Veridian Homes’s success.

At the same time, the company is constantly on the lookout for new ways to improve quality of the processes, techniques, and materials used in building homes. So far, the efforts have paid off. For example, Veridian Homes recently reduced construction defects by over 50%. In national surveys conducted by Avid Ratings, Veridian's customer satisfaction scores consistently measure in the top 10% of more than 300 builders.

Figure 2. Pictured from left to right: John Maasch, VP of sales and marketing; Dan Gorski, VP of home services, purchasing and design; David Simon, president of operations; Bill Bublitz, VP of finance and information technology; Jeff Rosenberg, president of land and acquisitions; Gary Zajicek, VP of construction and customer relations; Don Espositio, VP of land development.

Communities and Design

Veridian Homes focuses on developing environmentally sensitive, smart-growth communities that feature a mix of housing products that mesh with traditional neighborhood design principles. A strong regional proponent of small-lot ordinances, the builder currently has 21 neighborhoods under development in the greater Madison area.

"Primarily, our neighborhoods are designed using the concept of new urbanism," says David Simon, president of operations. "This is really all about knitting together a variety of housing choices, businesses, and recreational opportunities into a well-rounded community with a town-square focus."

The company has taken traditional architectural styles, such as bungalow and craftsman, and blended them with contemporary styles, Simon says. Diversity of home styles and colors is encouraged. For example, Veridian selects rich exterior colors for its models and spec-built homes to demonstrate the beauty of bold colors and to encourage buyers, who may have difficulty visualizing the finished product, to do the same. As Dan Gorski, Veridian's vice president of home services, purchasing, and design says, "Many people are afraid to go too bold with their color selection, but a sea of grey-sided homes can become monotonous."

The builder also enforces a strict anti-monotony policy for single-family homes: no two are repeated within seven lots in any direction. Other features that add character to each community include wrap-around porches and variation in garage location. For narrow-lots, side-yard windows are carefully sized and positioned to bring in natural light without sacrificing homeowner privacy. Plans are constantly being reviewed, says Gorski, not only to improve construction efficiencies but also to keep the builder on-track with consumers' changing tastes and demands. The company employs its own staff architect to develop new plans and refine existing ones.

"We researched benchmarks from across the country on the newest and best designs as we developed our series of plans," says Simon. "We also listen to our consumers through surveys and focus groups of current homeowners. We ask them for their comments on how things are working for them and for suggestions on what they would change. Then we act on their feedback."

Quality Management

The cornerstone of Veridian Homes' success is its extensive quality management system that spans not only traditional quality, but also the areas of health, safety, and the environment. Its Quality, Environment, Health and Safety (QEHS) management system focuses on adopting business improvement practices and processes to enhance decision making company-wide to meet strategic and operational objectives. It is a system that spans all aspects of the company, from trade contractor relationships and jobsite safety to employee well being and construction scheduling.

Quality Management Tools

Detailed scopes of work—which include construction drawings, photos, and installation instructions—helps ensure correct and consistent installation and reduces defects. Detailed scopes are particularly important when implementing high performance home construction methods, such as lumber-saving framing techniques and careful duct installation. Interestingly, trade contractors have partnered with Veridian Homes to develop field-friendly, understandable and useful scopes of work.

Detailed scopes of work, together with monthly trade meetings and inspection forms for each stage of construction (job ready, in-process, and job complete), ongoing training, and working groups that include trades and Veridian's construction and warranty teams, have minimized defects and reduced construction costs. The company fosters teamwork that is at the core of the company's success and a major factor in its ability to build cost-effective, high performance homes.

Red Line Review

Veridian Homes does not simply mark its plans with red ink. Instead, it starts its quality improvement process at a formal, team-oriented red line review. To make the process efficient, Veridian conducts a "kaizen blitz" red line review, in which a large, cross-functional group of people focus on improving several home plans within a concentrated time frame. During the kaizen blitz, the construction, customer relations, and drafting departments, along with trade partners, identify opportunities for improvement in the building plans. These recommendations often lead to improvements in customer satisfaction and construction process efficiency. Kaizen blitzes are conducted on all new plans and regularly throughout the year on existing plans.

"We are not perfect," says Simon. "Nobody is. And our quality improvement process is not about achieving perfection. What it is really about is how we can build a better product for our customers, take information about our weaknesses and then build better systems around them."

Following Excellence Criteria

Veridian Home's strives to improve quality by following the guiding principles of the Malcolm Baldrige National Quality Award Criteria for Performance Excellence; by participating in the National Housing Quality Award (NHQA) program, which includes a third-party assessment; obtaining customer feedback through surveys and focus groups; employing Six Sigma methodology; and through process mapping. During an annual strategic planning meeting, the company also conducts a SWOT (Strengths, Weaknesses Opportunities & Threats) analysis.

In 2004, Veridian Homes was one of three builders nationwide to earn Certified Builder status by the National Housing Quality (NHQ) program for its Quality and Safety management systems in its construction, sales, and customer relations departments. Since then, it has earned NHQ status beyond the minimum requirements to include its environmental management systems in its land development, design, estimating and purchasing departments.

Participation in the NHQ Certified Builder program is designed to increase efficiency and consistency in building practices. Certification, based on the international ISO 9000 quality standards, is achieved through a rigorous third-party audit of a builder's business practices. This audit determines if all elements of the company's quality assurance system are integrated throughout the construction process.

In 2006, the company earned the NHQ Gold Award, the housing industry's highest recognition for quality achievement and world-class business practices. NHQ entries are judged by industry experts who evaluate the role that customer-focused quality plays in the builder's construction, business management, sales, design and warranty service.

Facilitating Communication

Veridian Homes relies on the ideas of its employees and trade contractors to keep the construction process operating smoothly. To that end, it promotes frequent and effective communication through a coordinated schedule of monthly, bi-weekly and weekly meetings between senior management, departmental managers, employees and trade partners to discuss goals, strategies, timelines, and action plans. Feedback from employees and trade partners is highly encouraged and helps the builder identify Opportunities for Improvement (OFIs).

Quality Toolbox

Veridian Homes has developed a "quality toolbox" that facilitates employee participation in the company's quality initiatives. The quality toolbox focuses on developing, launching, and implementing company-wide business improvement practices and processes, including:

- Tools and resources for personal and professional growth
- Quality improvement training for all employees that guides understanding of the methodologies embraced by company management

"We want to make sure that as we continue to grow as a company, we continue the quality," says David Simon. "As we have success, we are constantly refining the toolbox so that we don't lose our quality platform." The company uses a variety of methods for checking and improving quality including feedback from surveys of employees, trade partners and customers.

Self-Assessment and Strategic Planning

Veridian treats self-assessment as an integral part of its strategic planning process (SPP). Strategic planning starts and ends with self-assessment as part of the interactive communication between senior management and employees.

Senior managers lead regular companywide self-assessments using the Baldrige Criteria for Performance Excellence. Resulting data are used to identify strategic and operational opportunities for improvement (OFIs) while monitoring corporate performance through a balanced scorecard of performance metrics. This process drives continuous improvement and forms the basis of Veridian's strategic planning structure.

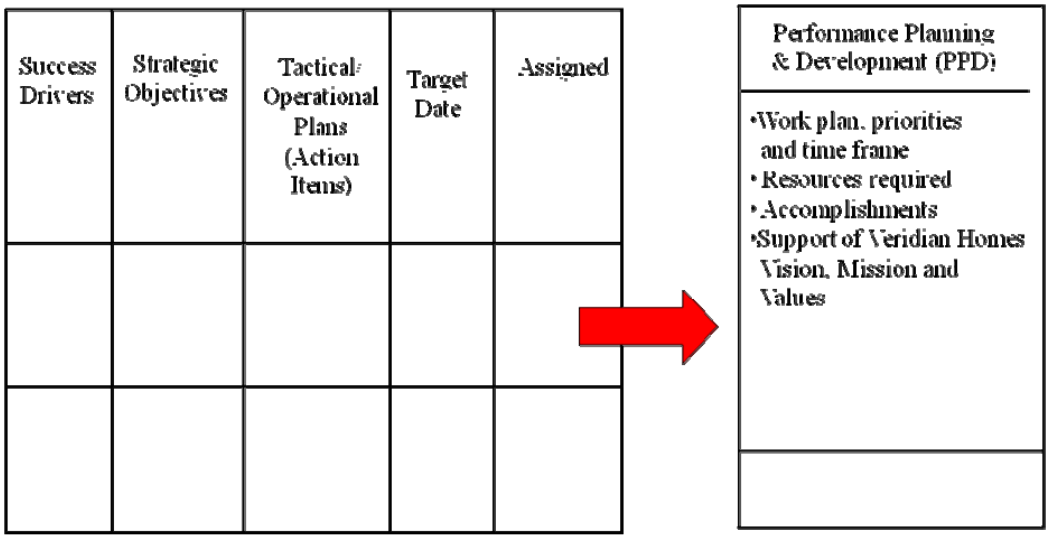
Self-assessments are conducted annually using Baldrige Express, an online employee survey based on the Baldrige criteria. Veridian's Baldrige Express survey is conducted by the Wisconsin Forward Award program under administration by the National Council for Performance Excellence. This online survey, organized by sections that align with the Baldrige criteria, allows employees to rate the company under each criterion and provide detailed comments on strengths, weaknesses and OFIs. The detailed survey report allows management to conduct annual measuring and monitoring and to identify and prioritize areas needing improvement.

Veridian uses these Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis to drive its annual strategic planning, placing the Baldrige criteria at the heart of its organizational strategy formation. The strategic planning involves senior managers meeting off site to evaluate the SWOT analysis and develop a strategic environmental scan using the company's values, vision, and mission statements to evaluate and direct the process. Senior managers communicate key decisions from the strategic planning sessions to the management team at a second offsite meeting. At this meeting, the managers further discuss goals and timelines. Managers then present this information to their departments to ensure all employees understand and further refine the company's strategy.

Managers obtain feedback on leadership effectiveness through various mechanisms, including regular meetings, an in-depth employee satisfaction survey, and a leadership 360 degree evaluation. Conducted every 18 months, the employee satisfaction survey allows employees to confidentially rate and provide detailed feedback on a wide range of issues. The feedback, in turn, is used to constantly improve the satisfaction of the team and their work. Every manager is assessed by a 360 degree evaluation in which supervisors, peers, and those they manage rate the manager's performance on a range of issues.

After determining the strategic objectives and aligning them with "success drivers", managers create departmental goals, timelines, and action plans to ensure effective strategy rollout. Action plans dictate how objectives will be implemented, target completion dates, and who is responsible for meeting each goal. Strategic goals are linked to each employee via the performance planning and development (PPD) process. The PPD helps each employee understand his or her role, priorities, resources, accomplishments, and professional development as they relate to the company's vision, mission, strategic drivers, and departmental strategic goals. A profit sharing program helps motivate and reward employees based on measured and sustained improvements in cost, quality, cycle time, customer service, and profit.

Veridian employees also have input to the SPP at monthly and weekly departmental meetings, biweekly company meetings, and weekly one-on-one meetings between employees and management. During each bi-weekly company meeting, the company's vision and mission are reviewed, each department provides an update, and quality is discussed.



Strategic Plan Directly Linked to PPDs

Strategic Plans Linked at Many Levels

Weekly production meetings are conducted with trade contractors to review schedules and address hot spots or emerging problem areas. These meetings, which highlight the production process as a team effort instead of a series of disjointed activities, are directly responsible for improving communication and cooperation and reducing cycle time and construction defects.

At an operational level, the integrated QEHS management system, which is based on ISO 9001, ISO 14001 and OHSAS 18001, is linked to other quality tools such as the Six Sigma methodology DMAIC (Define, Measure, Analyze, Improve, and Control), value stream mapping, problem solving, 5S (sort,

straighten, shine, systemize and sustain), and 8D (eight disciplines of problem solving). The QEHS management system provides the means for Veridian to design, manage, and improve its business processes.

Veridian improvement tools & techniques

These tools support quality implementation. They are available on the corporate intranet to all employees, and include:

- PowerPoint-based quality improvement training materials
- Videos
- Trade partner certification materials
- Builder certification materials
- NHQ Performance Criteria
- Baldrige Criteria for Performance Excellence
- Six Sigma DMAIC process
- Plan-Do-Check-Act
- Process maps
- Value stream mapping
- Failure Mode Effects Analysis (FMEA, a risk evaluation tool).
- 5S
- 8D
- ASQ's International Team Excellence tools
- TRIZ (problem solving methodology)

Improvement Teams

Over 36 cross-functional improvement teams, comprised of a total of 76 employees, have completed projects to reduce cycle time and create new customer materials. Each team includes a leader, facilitator, sponsor, and trade partner. Each team member participates in 16 hours of communications and quality management training before the team develops its charter. Appropriate improvement tools, shown in the sidebar, are used within the team to implement changes and identify root causes of problems. Teams create and implement long term plans for corrective and preventive action which not only help the company's bottom line, but also have direct positive impact on the environment, customers, and the community.

Process Maps

To create consistent processes and improve existing processes, the company has developed more than 25 process maps and departmental action plans. Process maps are supported by 1,500 action plans and detailed scopes of work and specifications for every aspect of the business. These documents create a foundation for agreed ways of working, consistency, and the basis for ongoing improvement.

Internal Quality Audits

Quality audits are conducted internally every six months (as part of the QEHS management system) to ensure that the quality management systems are working effectively and efficiently. These audits are not about policing employees, but rather about seeking what's working, sharing that learning, seeking ways to improve, and fixing what isn't working. Internal audits, which help drive improvement, are built on daily tracking of defects, customer communication, and other metrics to have traceability for the future (i.e., for insurance purposes).

Focus On High Performance Homes

When it comes to protecting the environment, Veridian Homes takes its role very seriously. "Green building is a part of our business culture, says Simon, "and we believe that it is the right thing to do." As evidence, all of Veridian's homes and condominiums are built to Green Built Home and ENERGY STAR

program standards.

Veridian Homes also participates in a variety of green building programs on local, state and national levels including the U.S. Green Building Council's Leadership in Energy and Environmental Design for Homes pilot project. It was officially recognized as a participant in Wisconsin's innovative Green Tier program, a Department of Natural Resources-administered program designed to reward businesses that differentiate themselves by systematically delivering superior environmental performance with economic benefits.

The standard of energy efficiency is reflected in the numerous EnergyValue Housing Awards that it has won for every type of home it builds. “Veridian hasn’t just built a few energy efficient homes. They do it in all of their houses and that’s very unique. To be ENERGY STAR compliant in everything you build takes a company-wide commitment,” says Debra Sagan, EnergyValue Housing Award program manager.

“Veridian Homes systematically goes through every part of the building process and the materials it uses to figure out how to reduce the overall footprint of its homes,” says John Imes, executive director of the Wisconsin Environmental Initiative which administrates the Green Built Home program.

In a business where many builders look at green construction techniques as a money pit with limited return on investment, Veridian executives have staked the entire company on building green without adding to construction cost. In fact, the company’s average square foot construction cost is just $76 compared with the national average cost of $90 per square foot and the Midwest average of $88.

For Mark McDermid, bureau director for cooperative environmental assistance at the Wisconsin Department of Natural Resources, the difference comes in Veridian’s deliberate approach in marrying environmental and economic savings throughout the construction process. “The differentiating factor for Veridian Homes is that it is not a random undertaking but a very holistic approach to managing environmental performance,” McDermid says. “And they don’t sacrifice the economics of development activities to do so.”

As Simon puts it, “For us it’s always been about how we can be a better builder and a better steward of the environment. We are still a for-profit builder. But we also believe that you can marry those philosophies together so that you can be profitable and still be environmentally conscious.”

Recycling

As an example of its environmental stewardship, Veridian Homes has initiated a cooperative effort with trade partners to recycle scrap wood, vinyl siding, cardboard and concrete. As a result, it recycles over half of its construction waste, and more material than any other builder in Wisconsin. It also devotes ample time and resources to land planning, habitat restoration and water conservation to restore the harmony between new communities and the environment.

"You have to consider both. Making the decision to build green does not have to be a costly one for the customer if you go about it in a systematic way. You have to ask yourself, 'How can I improve this product without raising the cost?' It is not so much about having to use more expensive products as it is about making sure that you are using the proper installation methods and can meet third-party inspections. Ultimately, the most important thing is to make sure you are providing a high-quality, comfortable living environment for the consumer and that the home is truly performing the way it should," says Simon.

When it came to convincing construction trade crews that recycling was a good way to be kinder to the environment, it wasn't always easy for Gary Zajicek, Veridian Homes' vice president of construction. "Initially, getting participating in jobsite recycling was like pulling teeth," says Zajicek. "Most of these guys were coming from a background where it was throw-anything-extra-as-far-as-you-can. As a result, we would end up with tons and tons of waste. We tried over and over again through our discussions and on-site training to get them on board. We would see a little success, and then it would fall back again. But we never gave up."

For Zajicek, the turning point occurred during a presentation to the company's trade partners on the merits of green building practices and erosion control. On the screen, he flashed an aerial shot of Lake Mendota, Madison's picturesque recreational lake that borders the city. "One half of the lake was blue and pristine and the entire other half was muddy brown. Their jaws just dropped. I said 'Do you see what is going on here? This is a silt plume coming from the construction sites in Madison because of the lack of green environmental practices. Now let's go over what role you play in this each time that you are on a job site.' That one slide did more convincing than two or three years' worth of talking."

In addition to establishing a "willingness" to recycle by reinforcing the concept during its weekly meetings, the builder also introduced a financial incentive. The company evaluated the framing process and determined acceptable waste. "When a new home is built, the framing contractor gets one, 8-cubic-yard dumpster for scrap wood," says Zajicek. "If they need another dumpster, then they are responsible for paying for its removal." According to Zajicek, this new system caught on fast because if the framers were not doing things efficiently, it cost them. "Ultimately, we have created a win-win situation for everyone because material costs and landfill costs are down."

The builder has also set up a central collection area in each of its communities under construction to collect scrap vinyl, drywall, concrete and cardboard. "We ask them to help us recycle these materials, and now they do," says Zajicek.

Green Features

No matter what color the exterior is, every home that Veridian Homes builds is green on the inside. By specifying recycled or high-efficiency products where it counts, making better use of materials and reducing waste, a builder can play a big role in reducing pollution and conserving natural resources, says Simon. "The process starts during the planning and design stage and continues right through to how that home functions for its owner."

In its high performance homes, the company uses:

- Engineered wood products to reduce the need for long spans of dimensional lumber
- All homes include housewrap with taped seams as a moisture/air infiltration barrier
- Blown cellulose attic insulation that contains more than 75% recycled material
- Thermal breaks in concrete basement walls
- ENERGY STAR-rated HVAC equipment
- Gas fireplaces with non-standing pilot lights
- Programmable thermostats
- Exhaust ventilation timers
- High performance windows
- Carpet with the CRI's IAQ (indoor air quality) label
- Low-flow faucets and showerheads
- Low-VOC paints

Veridian Homes practices what it preaches. For example, rather than constructing a brand new headquarters for its operations, it opted to renovate an abandoned furniture store. The sleek and modern facility features office and meeting space and an award-winning design studio. The headquarters, designed by office furniture innovator Herman Miller, features a visually striking "open office" concept that promotes worker creativity, conversation and community. Employees are grouped in unique neighborhood arrangements that provide opportunities to hold meetings in "backyards" rather than in enclosed meeting rooms.

Safety Management

Together, the NHQ Award winning and Certified Builder criteria provide the means by which Veridian drives improvement and designs and manages the business safety processes. Six times per year, Veridian's Builder Certification Team (composed of manager representatives from each department) reevaluates and updates processes within the Quality Environmental Health and Safety (QEHS) management system. The processes addressed by the QEHS management system link to Veridian's Strategic Planning Process and are crucial to the integrated operation of the company. In addition, these processes keep safety at the forefront of the minds of managers and employees. This safety program earned the NAHB Safety Award for Excellence.

Owners and managers take responsibility for the safety program by leading bi-weekly company team meetings and various department and trade meetings where safety is discussed. For example, the vice president of construction emphasizes safety practices through weekly meetings with trade partners and weekly construction manager meetings. In turn, construction managers' leadership drives and reinforces jobsite safety every day.

Veridian emphasizes safety and health through its Safety Team, comprised of employees and managers representing a variety of roles and departments. Some initiatives sponsored by the Safety Team include maintaining an accurate Materials Safety Data Sheet (MSDS) binder and obtaining a defibrillator for the office. The team also organizes frequent, timed fire and tornado drills. Measuring evacuation times helps the company improve safety by creating more efficient evacuation routes. Integrated into all aspects of the company, the QEHS management system is the epicenter of Veridian's safety program.

The QEHS management system empowers Veridian to operate effectively and safely through detailed scopes of work, training, and inspection guidelines. The inspections identify patterns of nonconformance. For example, mandatory Site Safety Spot Checks are conducted by construction managers four times per week. These checks ensure that safety standards are being adhered to in the field and provide leadership and role modeling for safe sites. This also includes education on the job to reinforce safety.

High trade involvement (supported by the NAHB Research Center Builder and Trade Partner Certification programs) helps further integrate safety directly onto the job site. Construction managers communicate regularly via Nextel with trades, customer relations representatives, and other Veridian representatives throughout the day to ensure thorough knowledge of any issues that arise. Safety issues are addressed through the Safety Violation Monitoring of trades: the vice president of construction speaks with trade owners after three safety issues are reported. If a situation is deemed "unsafe," trades stop work until the site is safe.

As "mayors" of specific neighborhoods, construction managers focus on job site progress, cleanliness, and site safety compliance of trade partners and Veridian employees. Each has safety manuals, hard hats, and first aid kits in their vehicles in case a safety issue arises. (All furnished models within the neighborhoods also have first aid kits, hard hats, and fire extinguishers). Construction managers also conduct rotating audits on site for their neighborhoods. These audits are reinforced through third party (National Housing Quality) audits.

To drive improvement, teams comprised of construction managers and representatives from trade partners formulate and address Opportunities for Improvement. Examples include recurring issues and new initiatives to help a trade group or company adapt to new OSHA requirements. Through this process, new fall safety requirements for siding and gutter crews were established. This approach builds trust and promotes resources and expertise to Veridian's trades so they can quickly implement requirements. An online OFI form (under development in Veridian's award-winning HomeTracker system) will allow corrective and preventative tracking of issues that arise.

Company-wide safety and health training is driven through the Safety Team initiatives as well as the annual First Aid/CPR/AED Training. The Safety Team conducts regular safety preparedness training during the bi-weekly company meeting. In this setting, key tips and advice on work and home safety issues are addressed with the whole company. The team also emails occasional safety updates to the entire company. As a company, Veridian focuses on key safety issues specific to the season (i.e., during the summer Veridian focuses on the dangers of high temperatures and provides water on site for crews).

All construction and customer relations department employees have completed the America Red Cross First Aid/CPR/AED training. This training, available to all employees, is required for the construction and customer relations departments due to their increased contact with the building process and customers.

Much of the ongoing safety training is conducted within the construction department. For example, the entire construction department has completed the 10 hour OSHA construction safety and health program, including the production managers and the vice president of construction. Veridian's safety director has also completed the 30 hour OSHA site safety training and is a certified UDC code inspector.

Safety is a regular item on the agenda at weekly meetings, which allows Veridian to provide training and awareness to all trade partners. Handouts, jobsite safety photos, videos, PowerPoints, and interactive games are all used for training on safety. Safety speakers, such Veridian's insurance provider or an OSHA representative, often present at the weekly meetings. The monthly OSHA Safety Newsletter is also shared during the meetings.

The weekly construction managers' meeting drives safety training and utilizes "Practice, Drill, and Rehearse" to obtain hands-on experience in a controlled environment. Veridian's annual, one-day Trade Partner Conference includes a session on safety. Regular emails with safety tips and information are also shared with trades.

"Some companies cut and paste their names onto a sample safety program and call it their own, but Veridian's safety committee debated every part of the program to ensure it was in the best interest of Veridian and its trade partners. This program has been edited and altered over the last two years in order to stay current and provide the most up to date guidelines for all who are affected," says Ken Alderden, senior risk control manager for Murphy Insurance Group.

Veridian provides a variety of complimentary resources for its employees to lead healthy lives: an on-site fitness center, Work-Life Matters counseling, annual flu shots, and a Wellness Program with consultation sessions for employees and significant others.

Employee Focus

Veridian's hiring practices are based on considering a candidate's unique skill set and assessing their potential to embrace the company's vision and mission, rather than concentrating solely on industry experience. "We begin by determining how they will fit into the unique business culture we have established here and then educate them on our processes," says Simon.

Setting Employee Expectations

Customers are not the only ones who know what they are getting with Veridian Homes. By setting specific goals for each employee and linking these goals to the company's performance planning and development process, each worker has a clear picture of his or her role. The process helps establish priorities and identify resources, accomplishments, and opportunities for professional development. Employees are rewarded through participation in a profit-sharing program based on sustained improvements in cost, quality, cycle times, customer service, and company profit.

Weekly one-on-one meetings between department managers and their employees present the opportunity for open discussion about anything affecting job performance. The one-on-one forum allows managers to focus on each employee and to identify job-related or personal frustrations early on. The meetings provide managers with constant feedback about which processes are working and which are not, and helps mitigate the escalation of minor problems.

While the multitude of scheduled meetings may, at first glance, seem to be a time bandit, says Simon, it is actually the exact opposite. "When you start holding meetings in a structured format, it actually frees up a lot of time. People tend to hold the line on complaints and their need to share information

haphazardly when they realize that there will be a set opportunity to do so every week. Questions are addressed and answers are given."

Satisfied Customers

Veridian Homes never loses sight of the importance of the buyer in the home building process, says Simon. "Consumers are individuals to us and we do our best to consider their unique needs. Yes, we have specific systems in place for building their home, but we also recognize that there has to be a certain amount of interaction with them during the process as well. We look at their personality type, identify how involved they want to be, and then do our best to accommodate that.

"We still have to meet our deadlines, but we have found that by listening to the customer, we learn a lot about what their expectations are and how we can meet them. We make sure that we are reaching out to our buyer in a variety of ways as their home is being built."

Planned interactions between builder and buyer take the form of a carefully orchestrated series of handoffs from one specialist to the next as the home moves from stage to stage. The team still exists in the background, but a specialist in sales, design coordination, construction management or customer relations takes a lead role in working with the buyer at various stages before and after they close on their home.

Interacting with the buyer also provides the opportunity for education, says Simon. "Before a buyer moves in, we have a customer service representative demonstrate to them what is unique about their home and how its systems are designed to function. Education is very important in order for the consumer to get the best results."

A satisfied customer is the most valuable sales tool of all when it comes to attracting new buyers, says Simon. In just four years, Veridian Homes achieved brand recognition in its region of 94% and a customer satisfaction score of 95%.

Community Involvement and Philanthropy

Veridian Homes is a strong proponent of community involvement, contributing $250,000 annually to not-for-profit charities and organizations through its own foundation. Over the years, the company has sponsored an annual raffle for Big Brothers and Big Sisters of Dane County in which a home built by Veridian Homes is the grand prize. The raffle has netted more than $2.5 million for the charity. Veridian Homes has also donated $1 million and a site for the construction of a new YMCA facility in Madison.

Figure 3. One of Veridian Homes's traditional neighborhoods.

Construction Management

Even Flow Production

Using impeccable project management and planning and strictly adhering to construction schedule, Veridian has developed its own even flow production system that reduces fluctuation in on-site workload. Techniques such as balanced trade partner scheduling and just-in-time materials delivery allow the company to reduce the number of return trips for trades and callbacks to the job site and increase the reliability of material availability.

Under the even flow production system, customers are guaranteed a closing date—and a fixed sales price—on the day of contract signing. "Customers know from the start exactly what day they can move in," says Zajicek. "In fact, they know what day the concrete basement is going to be poured and what day the carpet is going to go in because these dates have been set. What we have done is evaluate the building process from the closing date backward. Every step of the process is assigned a set date that we have all agreed to stick to."

Initially, the even flow concept was met with skepticism by trade partners. "There was apprehension and doubt as to whether or not something like this would actually work," says Zajicek. "It did take some convincing to get them on board and several months of trial and error to get it right."

In the even flow process, the construction management team holds weekly meetings to evaluate scheduling with trade groups that are divided into beginning, mechanical, and finish categories. All trades meet as a group during the fourth week. Discussions include scope of work, review of completed work, and identification of jobs that are coming up.

"These weekly meetings were initially set up to bring together the scheduling and verify its accuracy," says Zajicek. "As even flow has become more and more accepted by the trades, we discuss the schedule less. The meetings have now become a means of educating our trades on exactly what our expectations are, of sharing ideas and identifying areas for improvement."

Similar to their uncertainty about the scheduling process, Zajicek met significant trade partner reluctance when it came to their required participation in the weekly meeting schedule. "We take participation in these meetings seriously and we address this right from the start, beginning in our interview process with them. When trade partners sign a contract to work with us, they understand that they will be joining us in these weekly meetings.

Construction Process Innovation

Research and development, a term not typically associated with home building, is another benefit of the company's process-driven approach. According to Simon, their systematic approach to construction provides more opportunity for experimentation with new concepts and technology in spec-built projects. "It really allows you to better benchmark, track results, improvise and try out new ideas."

In terms of process innovation, Veridian has experimented with improved framing techniques that reduce the amount of lumber required to build a home, built a test home using Q.A. Duct—a new plastic-based ducting system, received an exemption from the Wisconsin Department of Natural Resources to allow grinding of oriented strand board (OSB) with dimensional lumber for use in erosion control "socks" and as ground cover on construction sites, and is testing a recycled and recyclable plastic grid system as a replacement for stone as an erosion-control pad on construction sites. The company has also built six LEED for Homes-certified homes.

Building a Trade Partnership

"Most home builders don't really build anything," says Simon, "we manage a process, people, and expectations. Our trades are really the ones who come together and build the home, so we are putting a lot of responsibility in their hands in terms of what we will eventually provide to our customers. Therefore, the relationship we have with our trade partners is crucial."

To foster this relationship, the company has developed a culture of "helpful engagement" with its trade partners that is beneficial to both parties. "This is unlike the typical environment they are familiar with," says Simon. "Our message to them is, 'How we can be of help to you in doing your job better?'"

To this end, Veridian Homes encourages its trade partners to refine management practices and improve their own business practices by promoting, supporting, and paying for certification classes and training materials under the NAHB Research Center's NHQ Certified Trade Contractor Program. To date, 80 trade partners have been trained and have implemented quality management systems, 22 have achieved NHQ Certified Trade Contractor status, and many others are preparing for certification. As trade partners adopt more professional business practices, Veridian Homes has been able to reduce project oversight.

Veridian has also formed its own 15-member Trade Partner Advisory Council. The council, which includes a representative from each home building function, meets monthly to discuss concerns and provide feedback. Partners are encouraged to bring their ideas for using new products and innovative green building techniques. Veridian hosts an annual Quality Improvement Conference in which keynote speakers, Veridian Homes staff, and trade partners share ideas and present best practices.

As part of its continuous improvement, the company includes a trade partner representative on many of its cross-functional improvement teams and solicits feedback through regular surveys on how Veridian can improve its operations.

The following diagram shows the range of issues that Veridian Homes focuses on to build its relationships with its trade partners.

Information Technology

Design Technology Software

Veridian Homes has taken full advantage of computer technology. One example of the power of information technology was their adoption of Revit Architecture software. Says Gorski, "Revit Architecture software is invaluable to the company's whole-house integrated design approach. With the software, designers create a three-dimensional virtual prototype of a building that is used not only for documentation but also for quantity takeoffs, scheduling, area calculations, and design visualizations." As plans are personalized for the customer, the software automatically updates documentation, construction schedules, and takeoffs. "With Revit Architecture software, we can quickly make changes to our standard set of building designs, get more accurate cost estimates, and let our customers 'see' their future homes," says Gorski.

"As we implemented Revit Architecture, we realized that we could integrate our design and estimating processes," says Gorski. Veridian Homes created new workflows that tapped the Revit Architecture model for precise quantity takeoffs—using that data to produce more accurate cost estimates. Designers, drafters, and estimators now all work with the Revit Architecture model, updating it to match incoming customer specifications or changes, and then producing new documentation and new cost estimates for the customer's approval.

Revit Architecture is also helping Veridian Homes communicate its designs more quickly and clearly. "We can change a design in real time and let the customer see the immediate impact of that change," says Gorski. In fact, one of the company's goals is to create 3D renderings of all its Revit Architecture designs and make them available to customers on the company website. "This will be a great tool—allowing our customers to really see what their house will look like," says Gorski.

Autodesk Buzzsaw software enables Veridian Homes to efficiently exchange information such as plans, specifications, selections, schedules, and purchase orders with its numerous trade partners. "We have over 250 users—from roofers to cabinet manufacturers to appraisers—using Autodesk Buzzsaw," reports Gorski. "With Autodesk Buzzsaw, we can get project information to them faster and more economically." In addition, Autodesk Buzzsaw promotes accountability by giving trade partners 24/7 availability to crucial project information and even an audit trail of information distribution. "Most of the guesswork has been taken out of our building equation," remarks Gorski.

Quality Management Software

Information technology has also been incorporated into construction, quality management, and customer service through Veridian Homes's custom designed HomeTracker program. This intuitive, field friendly, real time system allows data entry about defects and sends reports by email while updating company databases. The databases, in turn, provide graphical dashboards of defects organized by trade and by milestone providing an overview of real time companywide processes and allowing fast analysis and action. Furthermore, this custom program has standardized the terminology used to describe defect and repair issues among departments and trade partners. Currently, 400 defect types are tracked; in the past, more than 7000 defect types were tracked.

Using the HomeTracker system, field staff use palm pilots and PCs to enter data from the field and to photograph defects for training and communication. Defect data is entered via drop-down lists based on

the trade partner and defect type to facilitate quick and accurate standardized data entry. Although additional detail can be added, standardized lists ensure that classification of defects is consistent. Data is collected during inspections and is immediately uploaded. In turn, the software generates work orders for trade partners which are sent via e-mail in PDF format. Many trades receive these work orders immediately via hand held devices.

Within the software, responsibility for the defect and for the repair is assigned. This is a key feature—defect information is subsequently used to produce scorecards for trade partners that facilitate the quality improvement processes. This process has resulted in as much as 400% improvement in some trades.

Conclusions

Veridian Home's success did not happen overnight, but rather it was a gradual process through continuous improvement. The key to the company's success was the decision to adopt and adapt management tools and techniques to improve cycle time and employee and customer satisfaction, and to reduce defects and cost. Over time, these changes led to continual product improvement. Whether it's in design, construction, or safety, process improvement is at the core of the company's success.

The drivers for success at Veridian Homes have been:

- Leadership & Culture
- Quality Management
- Communication
- Employee Focus
- Customer Satisfaction
- Construction Management, High Performing Homes, Evenflow Scheduling
- Trade Partner Relationships
- Information Technology (to provide the gathering and analysis of data)

All of these have been driven and coordinated with a focus on designing and building High Performing Homes and managing the entire business on process improvement at every level.

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APPENDIX C: HIGH PERFORMANCE SCOPES OF WORK

High Performance Scopes of Work
Mixed-Humid Climate

INTRODUCTION

Scopes of Work

A Scope of Work is a description of the work that a trade contractor will perform for a builder. Every contract, including those executed with only a handshake, incorporates a Scope of Work, even if only verbal or implied. After all, if a builder did not need a task accomplished and did not describe that task to the trade contractor; there would be no basis for initiating an agreement. However, without a clear, detailed, written agreement between the builder and trade contractor, there cannot be any realistic expectation of performance because both parties often have significantly different expectations of the work.

Yet despite the problems caused by vague scopes of work, many documents in use today meet only the minimal legal and production requirements for the day-to-day new home construction operation. Many trade contracts used on the jobsite include more detail on insurance requirements, mediation requirements in the case of disputes, invoice processing, and change order processing procedures than they do on what work is expected to actually be completed by the trade contractor. In addition, builders and trade partners often view revising scopes of work to match current expectations or to coincide with the particular specifications of a project as more trouble than it is worth. Sometimes scopes of work are borrowed from others or copied from industry "boiler-plate" and used in trade contracts simply because the builder,"knew we had to say something". However, the cost of the status quo can be high. Small mistakes that must be found and corrected before progressing to the next trade cause inefficiency, expensive delays, and increased cycle time. Other mistakes, if left undiscovered, can be concealed in a closed assembly and create long-term consequences, which are often insidious and very costly.

These scopes of work are provided as general guidance to builders and trades. All scopes of work included in this document are intended to reference or adhere to manufacturer's installation instructions. Builders or trade contractors using these scopes of work must always comply with the manufacturer's installation instructions for specific products and applicable local building codes.

High Performance Homes

High performance homes, according to the U.S. Department of Energy's Builders Challenge, are those that "deliver comfort, quality, durability, and a healthy indoor environment consistent with the Department of Energy's Building America performance criteria." Years of research and practice by the Building America program and the

construction industry at large have led to the establishment of best practices for the production of high-performance homes[2].

However, it is challenging for builders to convey the non-standard construction details that are critical to building high-performance homes. It is even more difficult to relate how the work of the individual trade contractor company fits into the construction of a house that ultimately has to function as a system. Too often the trade contractor believes they are responsible only for their own work without concern for the other trades that also work on the project. When building high-performance homes, unambiguous design and construction details, complete and current scopes of work, and information regarding the interconnectedness of the trade partners, become crucial to ensuring the home's superior performance.

High Performance Scopes of Work

High Performance Scopes of Work must include unique requirements for design, specification, installation, and inspection and testing that, together, facilitate the construction of high performance homes. These scopes must highlight the impact of each trade contractor's work on the work of other trade contractors, and encourage trade partners to consider their work as part of a systematic process to build a home that exceeds minimum code requirements.

The High Performance Scopes of Work included here differ from conventional scopes of work in that they include:

- Industry-recommended best practices for design and specification based on the best available research for High Performance Homes, rather than simply code-compliant homes.
- Builders Challenge Quality Criteria.
- Coordination and integration between trade contractors, and between contractors and the designers or engineers, when required.
- Documented Job Ready and Job Complete inspection forms, and
- Job completion tied to successful performance testing whenever possible.

High Performance Scopes of Work–Applicability

This document introduces initial samples of High Performance Scopes of Work for builders and trade contractors wishing to build high performance homes. Although the High Performance Scopes of Work contained herein are limited to specific areas of the building process in the Mixed-Humid climate (as shown in Figures 1 and 2) the intention is to, over time, expand the scopes to encompass other climate regions and other trade contractor responsibilities. For now, when applying the sample High Performance Scopes of Work to other climate regions, details must be adjusted to reflect best practices for the climate.

[2] *Learn more about the Department of Energy's Building America Program online at* http://www1.eere.energy.gov/buildings/building_america/

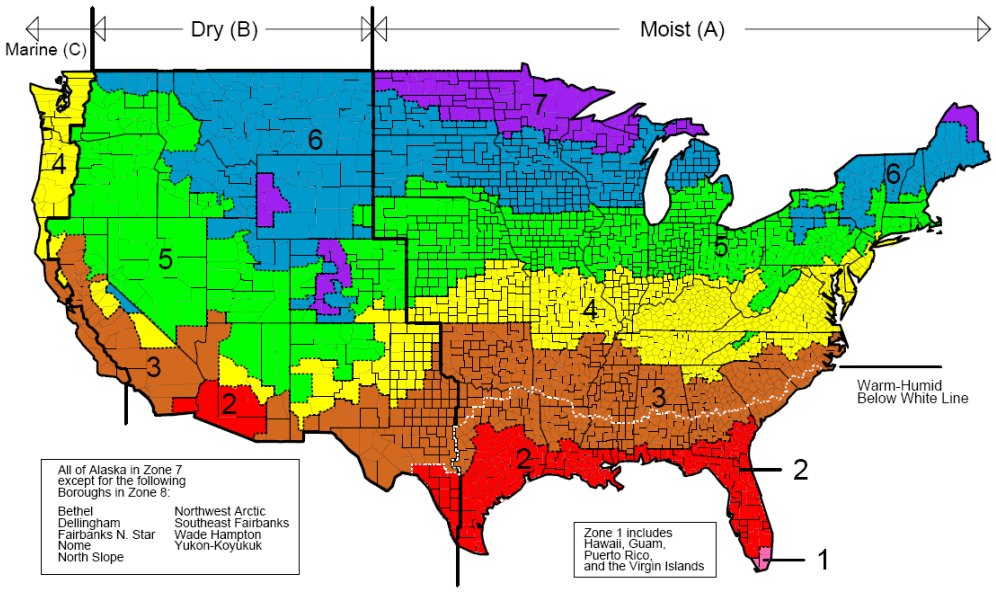


Figure 4. Climate Zone Map of North America

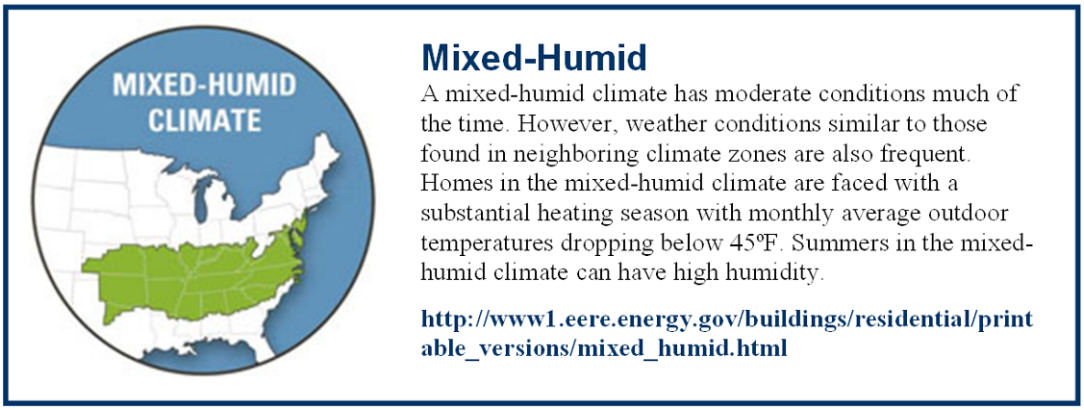


Figure 5. Mixed-Humid Climate Zone

These high performance scopes are developed based on Building America Best Practices developed under the Building America program. For more information about best practices for the Mixed-Humid climate, refer to Building America Best Practices Series Volume 4: Mixed Humid Climate, available at http://www.nrel.gov/docs/fy05osti/38448.pdf. For a list of climate zones by U.S. County, see http://www.energycodes.gov/implement/pdfs/climate_paper_review_draft_rev.pdf

These High Performance Scopes of Work do not replace builder and trade contractor code requirements, OSHA safety requirements, or any local, state, or national codes or laws. Implementing High Performance Scopes of Work does not guarantee compliance with any legal requirements associated with any part of the construction process. The sample High Performance Scopes of Work assume relatively moderate or standard engineering conditions only. Where extreme soil conditions, high wind, snow loads, or seismic loads exist, the user should consult a professional engineer. Although the 2006 and 2009 International Residential Codes and the 2006 and 2009 International Energy

Conservation Code were referenced during the development of these sample Scopes, local building code requirements should always be reviewed in conjunction with the implementation of any Scope of Work.

These High Performance Scopes of Work are intended to assist builders and trade contractors to build high performance homes efficiently and cost-effectively. They may be adopted and used in whole by a builder or trade contractor. These scopes may also be customized according to geographic region, construction methods, company size and culture, or other unique company specifications.

High Performance Scopes of Work–Organization

The High Performance Scopes of Work consist of six sections with each intended primarily for use by field or office personnel. Field and office documents are separated in order to succinctly provide instructional information to installers without including the legal and contractual elements necessary for the office. However, both field and office personnel should be aware of the provisions contained in all of the documents. The six sections of each High Performance Scope of Work and the personnel to which the section most directly applies are outlined in Table 1 and described in detail.

Table 3: Sections of a High Performance Scope of Work

Section	Office	Field
Design and Specification Prerequisites	X	X
Jobsite Conditions (weather conditions and other special considerations)		X
Assumed Order of Work		X
Contract Scope Language	X	
Job Ready Inspection and Checklist		X
Job Complete Inspection and Checklist		X

Design and Specification Prerequisites (Office)

The Design and Specification Prerequisites section includes all design work as well as material and equipment specifications that must be documented before trade contractor installation work can begin. Typically, design and specification work is completed by designers, architects, and/or engineers rather than by field installers. It is necessary to include information from this phase in the architectural plans so that the trade contractor can correctly install high performance measures.

Jobsite Conditions

Specific instructions for cold or hot weather installations will vary by local climate and by trade. For many trades, adjustments to their field installation processes based on weather conditions including temperature and humidity are a key to a high quality and durable result. Some trades are unaffected by the exterior weather conditions. Each trade contract Scope of Work needs to consider specific weather and site-specific instructions and include them as needed.

Assumed Order of Work (Field)

Part of writing a trade contract is to agree on expectations for both builders and trade partners. There are many ways to properly construct buildings in the field and many ways to split or assign responsibility for the work between the builder's staff, various

available trade contractors, and product suppliers. The scopes of work included in this report are all based on a set of specifications for the performance of the work under an interdependent schedule with many trade contractors. A particular builder may choose to re-allocate work or reschedule the order by which the field installations are accomplished. In such a case, revisions to these Scopes would be appropriate. (If the Job Ready Checklist requires inspection of another trade's work to ascertain readiness for the following trade it is probable that these two trades follow a critical path, or installation order, that should not be altered.)

Contract Scope Language (Office)

This section contains the specific language that can be cut and pasted directly into a trade contract, if the builder and the trade are in agreement on the order of work. Builder specific general conditions, insurance requirements, invoicing or change order instructions or dispute resolution provisions are to be added to this contract scope language as required by the individual entities that are a party to the contract.

Detailed job requirements and tolerances within a Scope of Work set builder-specific standards for safety, jobsite cleanliness, subcontractor coordination, and completion benchmarks. This section is also used to augment architectural drawings and to standardize material specifications and installation instructions. The Detailed Job Requirements and Tolerances section highlights critical elements that must be implemented in the field in order to achieve a high performance product. Industry-recommended best practices, coordination between trades, and ranges of acceptable performance standards/test results, where applicable, are included. Builders are urged to use the high performance strategies contained in this document as a starting point and to enhance the document with the input of their trade partners.

Inspection Checklists (Field) Purposes and Key Elements

Inspection Checklists serve multiple purposes including:

An installer's tool to help identify and correct his/her own mistakes during or immediately following installation.

A trade supervisor's tool to help identify and correct the installers mistakes during or immediately following installation.

A builder supervisor's tool to help identify unacceptable variations and develop a punch-list for corrective action.

To meet the Builders Challenge criteria, the Energy Star Thermal Bypass Inspection Checklist must be completed (BCQC-16).

A properly designed and utilized inspection form can demonstrate due diligence in complying with regulations, manufacturer's instructions, and workmanship standards. Both trade contractors and builders can use it to set expectations for successful completion while the completed Inspection Checklist can serve as a written record and payment release form.

The trade contractor's crew supervisor should use an inspection checklist to perform inspections on every job. Trade contractors performing several phases of work on a

house will prepare an Inspection Checklist upon completion of each phase. In addition, the builder can use a copy of the same list to perform quality inspections. If the trade doesn't have such a form, the builder and the trade should agree on the items to be inspected and verified and create the Inspection Checklist.

Both trade contractor and builder supervisors can also use the Inspection Checklist to evaluate trade contractor performance over time by tracking and evaluating the count and type of installation issues requiring correction over time. This information enables builders and trade contractors to see which installation challenges warrant the most immediate attention for preventive measures.

Jobsite Installation Record provides basic information about job location, start date, and the type of product or system that is to be, or was, installed. This is part of either a Job Ready or Job Complete Checklist.

Job Readiness questions verify there are no adverse conditions that impact quality and the job is suitable for work to begin. This should include availability of manufacturer's installation instructions and adequacy of work performed by previous trades, as well as building or environmental conditions that can affect quality.

Use of Materials should be documented. When materials affect quality, the inspection form should capture specific information on primary as well as secondary materials when they make a difference to the completed job.

Deviations detected should be recorded, even if they are corrected. All deviations from specifications should be noted. If a deviation is noted it should be followed by a corrected notation with date, and preferably a nonconformance photo and subsequent conformance photo should be taken.

The Job Ready Checklist[3], completed by the site supervisor and Trade Contractor, includes all items that must be installed or prepared on the jobsite by other trade contractors before work can begin. Although items in the Job Ready Checklist are not directly under the Trade Contractor's control, they directly affect the Trade Contractor's ability to successfully and efficiently carry out the work.

The Job Ready Checklist is an essential part of a High Performance Scope of Work because it highlights the ways in which one Trade Contractor's work is connected to another's and, thus, encourages Trade Contractors to think of their individual work as part of a larger whole.

The Job Ready Checklist creates accountability for trades since each Trade Contractor's finished product is reviewed with the builder and by the next trade in preparation for the next phase of work. At this point, incomplete or missing work can be identified and corrected before the next phase starts.

[3] It may be preferable for the Trade Contractor to develop the Job Ready Checklist in order that there is consistency within his/her company. However, the Builder should review the Job Ready Checklist to ensure that it captures the critical elements of the Scopes of Work Packages and their workflow.

Job Complete Checklist[4]

The Job Complete Checklist provides the mechanism by which the Trade Contractor certifies that work has been completed and the builder and trade contractor agree that the work meets the expectations set forth in the Scope of Work. To verify that the high performance features of the home were constructed correctly according to the Scope of Work, performance testing is often part of a Job Complete Checklist.

Job Complete Inspections verify that product manufacturer's installation instructions are followed and that workmanship meets expectations, because the inspection should include vital items from the installation instructions and measurement of acceptable tolerances. Whenever inspection questions verify conformance to dimensional specifications, actual measurements should be recorded. Inspections should also verify the use of specific equipment or tools if they affect quality results. Sign-off on the Job Complete Checklist should be done by the tradesperson after verifying each line of the list. Signature indicates completion, so repair items that are listed must be completed.

The Builders Challenge Quality Criteria from the DOE Building America Program have been incorporated into these Job Complete Checklists, such that a builder can use the Checklists to verify that the Builders Challenge criteria relevant to that trade contractor have been completed. Builders Challenge items are indicated throughout the individual Scopes of Work by gray shading on those items.

Builders and Trade Contractors should collaborate to prepare inspection checklists for each trade. The jobsite inspection process is an important element of a builder and Trade Contractor's quality assurance system to help build defect-free, durable homes.

High Performance Scopes of Work–Implementation Notes

As a general practice, any time Scopes of Work are updated or created, it is essential to have participation, review, and feedback from all affected parties, including builder's staff, trade partners, and suppliers to avoid unanticipated problems. Trade partners and suppliers, especially, are essential to the process because they are usually directly and indirectly impacted by changes. Even if a trade contractor or supplier is not directly affected by the scope, they may be indirectly impacted by a change in the construction process. Often, these indirect impacts can be difficult to predict and can affect trade partners, suppliers, or the builder in ways which are rarely foreseen, except by the affected company.

As materials change and construction techniques evolve, Scopes of Work must be regularly reviewed and revised in order to remain current. All builders are urged to review and revise their Scopes of Work into useful working documents that are not merely appendices to a standard trade contract.

[4] It may be preferable for the Trade Contractor to develop the Job Complete Checklist to provide consistency within the company. However, the builder should review the Job Complete Checklist to ensure that it captures the critical elements of his Detailed Job Requirements and Tolerances document.

Note on Implementation: A company will most efficiently and effectively implement high performance practices when it has a business management system in place that assures connection between all phases of design, construction, sales, and warranty; provides the necessary training to consistently perform the work correctly; and verifies proper installation and performance at every stage. A company must also have a process in place to identify and correct the cause of problems in order to prevent them in the future – not simply a punch list that marks the defect after the fact. Therefore, these documents are best suited for incorporation into a documented quality management program that stresses continuous improvement.

Builders Challenge

In addition to using these scopes of work to construct high performance homes, the six main sections of the scopes of work also contain highlighted items that can be used to verify the implementation of specific items required by the Builders Challenge program. The Builders Challenge program is used to certify homes to achieve at least a minimum level of performance that exceeds current efficiency requirements by 30% and to document performance levels as high as net-zero energy homes (ZEH). In addition to the energy performance requirement of the Builders Challenge, there is a set of Builders Challenge Quality Criteria (BCQC) representing high performance home best practices. Items that pertain to the BCQC included in these scopes of work are highlighted for easy reference. The complete set of BCQC requirements can be found at http://www1.eere.energy.gov/buildings/challenge/pdfs/bcqc_version_1_3_060408.pdf.

High Performance Scopes of Work–Development

The High Performance Scopes of Work are based on best practices developed under the Building America program.[5] There are two distinct steps in developing High Performance Scopes of Work.

Scopes of Work Content Development

The first step was to develop the content using industry resources and experts, which resulted in this final draft version of sample High Performance Scopes of Work. More specifically, this process included:

- Review existing scopes of work from high performance builders, industry standard practices, and Building America best practices
- Compare content and format typically used by builders for existing scopes of work
- Design a template for the Building America High Performance Scopes of Work
- Develop draft Scopes of Work

Scopes of Work Content Development Review

The second step in developing the scopes was a review of the draft High Performance Scopes of Work to incorporate construction details, Builder's Challenge criteria, and

5 *Building America Best Practices Series Volume 4: Mixed Humid Climate*, www.nrel.gov/docs/fy05osti/38448.pdf.

feedback from builders regarding their usefulness in the field. More specifically, this process included:

- Identify and locate graphics and pictures to supplement the Scopes of Work
- Review final draft Scopes of Work by industry experts and professionals including builders and Building America teams
- Review final draft Scopes of Work by high performance builders to determine usability (see below for details of this feedback)
- Review internally and edit to incorporate feedback of builders, trade partners, and industry professionals as appropriate
- Develop final Scopes of Work, incorporating feedback of industry professionals as appropriate

A draft of the draft Scopes of Work was sent to builders who were asked to provide feedback based on the following questions:

- Is the information contained in the Scopes of Work technically accurate
- Are the scopes useful for the builder or trade contractor
- Are any parts especially useful, such as illustrations, etc.
- How do these compare with the builder's current scopes of work
- Are they too complex, or not explicit enough, or is anything missing
- Would the builder use the proposed contract language as is, or as a reference to revise their current scopes
- General comments or suggestions

External feedback on the scopes was received from three residential builders and their comments were useful and helpful. The builders who provided feedback all had experience constructing crawlspaces and their overall feedback was very positive. The feedback confirmed that the technical approach and specifications were appropriate, and included suggestions for a few minor technical clarifications of the specifications.

Builders reviewing the Crawlspace Scopes of Work appreciated the level of detail, including the drawings and the inspection checklists. The builders indicated that the scopes would be useful to builders since "most builders will not have such an in-depth set of scopes", and one builder indicated that the Scopes of Work might set the example for developing other scopes within the builder's company. Another builder added that that the Scopes of Work would serve as a great base document for builders to modify to suit the specific climate, site and jurisdictional requirements of their particular area, "either for a builder looking to upgrade an existing Scope of Work or needing to adopt one".

Builders expressed appreciation of the step-by step approach of the Scopes of Work and that the documents including checklists and details would be available for download and modification by individual builders. One builder pointed out that having the template available would "save a lot of time" for builders. One reviewer suggested that

each trade's responsibilities be included in a portion of their particular scope of work, most likely with a subheading for crawlspaces, rather than having a separate Scope of Work just for crawlspaces, and this is in fact the longer term plan once scopes for all of the trades have been developed.

Comments were used, revised, or shortened to fit into the final document and the authors express their appreciation for the time spent in these reviews. As builders and trade contractors use these Scopes of Work, their actual field experiences will likely provide additional insights on how to improve the scopes, and any such feedback that is received will be incorporated into the website version of these documents

High Performance Scopes of Work–Resources

When seeking information about best practices, Building America program information was supplemented with residential construction performance guidelines[6] and by consulting experts in the trades addressed by this effort.[7] In addition to consulting leading industry resources, existing Scopes of Work used by builders were reviewed. The Builders Challenge Quality Criteria from the Building America Program was also incorporated. The final draft High Performance Scopes of Work were then drafted by the Research Center.

Quality Management and High Performance Scopes of Work

Quality work means doing the work right the first time. An accurate definition of the work requirements is a part of a quality program. A properly trained and instructed work crew with its managers accountable for a quality effort is also part of a quality program. Checking and confirming that required work is completed correctly is mandatory. Finally a method for continuously improving the process is a necessary part of a quality program. All these elements together make up an effective quality management system.

Rework, whether due to imperfect workmanship, improper handling by other trades, or a failure to communicate (such as incorrect product installation), is unproductive. Getting it right the first time is the goal.

[6] NAHB, *Residential Construction Performance Guidelines 3rd Edition.*
[7] See *Acknowledgements for industry expert who provided feedback on these scopes*.

Process for Quality Inspections–Resources

Job Ready Inspection Process using the example checklist provided

1. Builder and trade inspect job before work begin
2. All job ready conditions are verified or a follow up inspection is scheduled
3. Both parties confirm job is ready
4. Trade assumes responsibility for job conditions and begins work

Job Complete Inspection Process using the example checklist provided

1. Trade contractor leader on the jobsite completes or supervises completion of all required work
2. Trade contractor leader on the jobsite notifies trade supervisor that work scope has been reviewed and crew has completed the work
3. Trade contractor's supervisor inspects for completion of all contract work, deficiencies are noted and corrected
4. Builder's field manager inspects to confirm work is complete and acceptable, noted deficiencies have been corrected
5. Covering or otherwise protecting completed work by the trade crew is authorized by builder's field manager
6. Builder's field manager accepts work and approves progress payment
7. Builder's field manager schedules job ready inspection for next phase of work with next crew

Crawlspaces
Scopes of Work

General Introduction to Crawlspaces

Typical foundation choices for homes as well as high performance homes (HPH) include slab-on-grade, basement, raised piers or piles, and a crawlspace. Where a crawlspace foundation is selected, it is important that it be carefully designed and constructed, since it can have a significant impact on the overall performance of a high performance home. One crawlspace option for a builder is a traditional crawlspace that is vented to the outside. Another, option is an unvented crawlspace that is designed to minimize the passive entry of outside, unconditioned air into the crawlspace. The unvented crawlspace may be partially or fully conditioned by the home's space conditioning equipment. Whether as a traditional vented crawlspace, or an unvented crawlspace, the foundation choice plays a role in controlling moisture in the home as well as keeping pests and even pollutants, such as radon, out of the indoor environment. High performance home crawlspace construction integrates design and site preparation with moisture management, energy-efficiency, and mitigation of radon and other environmental contaminants.

Vented Versus Unvented Crawlspaces

Vented crawlspaces have long been the standard practice for crawlspace construction based on the belief that air vents in the continuous stem wall would allow any moisture within the crawlspace to dry as a result of air circulation. Field research in recent years has indicated that in some climates air circulation is an inadequate means of assuring a dry crawlspace. In addition, this research indicates that unvented crawlspaces in a mixed-humid climate are more energy-efficient than traditional vented crawlspaces[8].

Although vented crawlspaces are still built in far greater numbers than conditioned crawlspaces, current research suggests that the best practice is to build an unvented crawlspace in a mixed-humid climate. This is permitted by current versions of model building codes, and by better controlling moisture in the crawlspace, can result in increased comfort for the occupants and a more durable and long-lasting structure. A vented crawlspace may be recommended in situations where an unvented crawlspace is not appropriate, such as specific site conditions or climate zones. Some of the factors that may impact the decision include:

- Moisture management issues
- Whole-house energy performance considerations
- Location of the ducts and HVAC system within the conditioned envelope
- Radon mitigation and ventilation

[8] http://www.advancedenergy.org/buildings/knowledge_library/crawl_spaces/

Unvented Crawlspaces

Introduction

Building closed, conditioned, sealed or unvented (collectively referred to in this report as "unvented") crawlspaces is generally considered by current building science to be the best practice because under most conditions they help simplify addressing moisture and thermal issues, and allow HVAC equipment and ducts to be located in the crawlspace and remain within conditioned space. There are several different design variations that can be employed when designing and building an unvented crawlspace. Some design considerations include insulation specifications and installation location, HVAC equipment and duct location and means of conditioning the space.

Purpose of this High Performance Scope of Work

A High Performance Scope of Work for constructing unvented crawlspaces is designed to achieve the following:

Define the design and construction specifications that must be addressed in order to construct a high-performance, unvented crawlspace including: thermal insulation, equipment and duct location, moisture management, pest control, combustion safety, fire safety, and radon control.

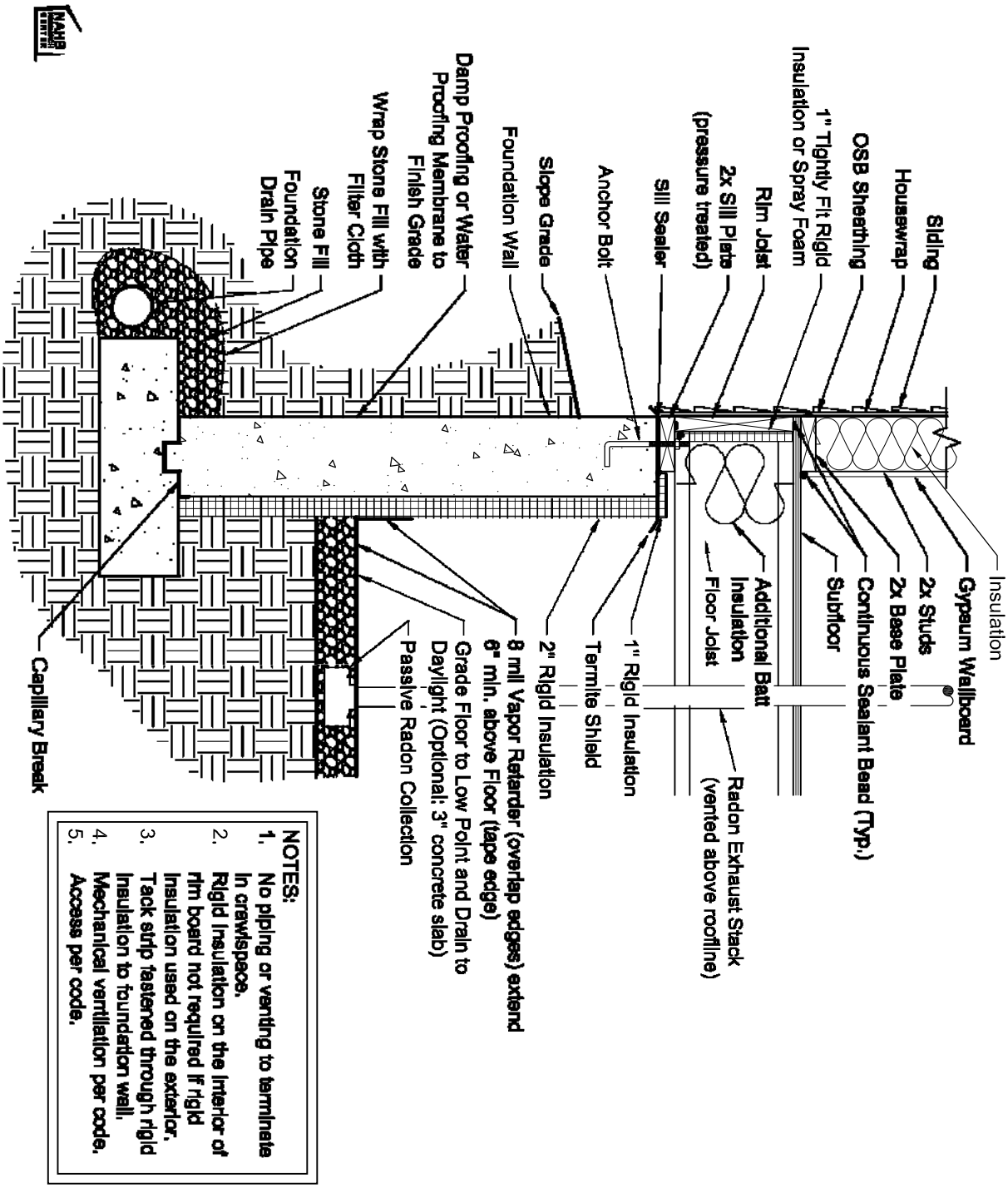
- Defining the expected work of several contractors such that roles and responsibilities of contractor and builder are clearly understood and both may be accountable for required performance. These are included as sections of each trade contractor's Scope of Work.
- Defining the conditions required for commencement of each separate contractor's work (Job Ready Checklists).
- Defining the conditions required for acceptance of each separate contractor's completed work (Job Complete Checklist).

Scope Content

A High Performance Scope of Work for the unvented crawlspace work is especially challenging given the large number of trades involved and the unlikely scenario where all required work will be included as a part of a single trade contract. This unvented crawlspace Scope of Work covers the following residential installation: an unvented crawlspace including thermal insulation, equipment and duct location, moisture management, pest control, combustion safety, fire safety, and radon control.

Any high performance home Scope of Work assumes certain field activities and an order of work. While these assumptions are not an integral part of the builder/trade contractor legal contract, these assumptions can make a useful training aide and become the basis for a field manager's checklist. (See Assumed order of work.)

Foundation Section - Conditioned (Unvented) Crawlspace



NOTES:

1. No piping or venting to terminate in crawlspace.
2. Rigid insulation on the interior of rim board not required if rigid insulation used on the exterior.
3. Tack strip fastened through rigid insulation to foundation wall.
4. Mechanical ventilation per code.
5. Access per code.

Builders Challenge

The Builders Challenge certification program is used to confirm that certified homes are designed to achieve at least a minimum level of energy performance that exceeds current efficiency requirements by 30% and to document their as-built performance levels, as high as net-zero energy homes (ZEH). In addition to the energy performance requirement of the Builders Challenge, there is a set of Builders Challenge Quality Criteria (BCQC) representing high performance home best practices. The complete set of BCQC requirements and the Builders Challenge Quality Criteria Support Document can be found at: Builders Challenge Quality Criteria Support Document.

A builder may also use the Scope of Work to verify that the Builders Challenge criteria relevant to each trade contractor have or have not been completed by each of their trade partners. Builders Challenge items are indicated throughout the scopes of work and checklists. They are denoted by a gray highlight. In addition, a note in italics accompanies the provision noting which Builders Challenge Quality Criteria the item addresses. For example, *[BCQC-2]* stands for Builders Challenge Quality Criteria item number 2.

Design and Specification Prerequisites

Unvented Crawlspaces

A. Unvented Crawlspace Moisture Management (BCQC-2 & 23)[9]

An unvented crawlspace must address several types of moisture management issues. The first of these moisture issues is bulk water entering into the unvented crawlspace that must be discharged to the exterior of the house and away from the crawlspace. Second, any moisture occurring in the unvented crawlspace must be effectively directed out of the crawlspace. Third, moisture vapor must be limited to the extent possible within the crawlspace.

Unvented crawlspaces that are air and vapor sealed limit condensation by controlling temperatures and moisture entry. Below are some best practices to manage moisture in an unvented crawlspace.

1. Shed/Keep Bulk Moisture away from the Foundation

- Install a roof rainwater runoff system that directs water at least 5 feet away from perimeter foundation walls.
- Ensure structural details and engineering suitable for the site and soil conditions. Local groundwater tables at their highest elevation should be below the lowest footing and foundation excavation. Design site grades that move water away from the foundation. Grading and landscaping should be planned for movement of rainwater run-off away from the home and its foundation, with a surface grade of at least 5% maintained for at least 10 feet around and away

[9] Builders Challenge Quality Criteria 2 requires consideration of water management in the design phase and BCQC-23 requires water management field verification. Water management per BCQC-2 & 23 is addressed in all of section A.

from the entire building. Swales, french drains, or storm drains can be used where houses are in closer proximity than twenty feet.

- Specify foundation plantings to be installed 18-24 inches from the building. Select plantings that do not require irrigation or use smart irrigation (sensors and soaker application) to minimize water applied around the foundation.
- Install exterior and interior foundation drains if the interior elevation is below finished exterior grade. Damp- or waterproof the exterior of the below-grade foundation to prevent moisture in the soil from migrating through the foundation.
- The exterior crawlspace access door should be protected from rainwater runoff and located a minimum of 4" higher than the exterior soil grade. Alternatively, the access door can be installed between the living area of the house and the unvented crawlspace.

2. Restricting Bulk Moisture in the Crawlspace

- Install condensate discharge pipes and exhausts from kitchens, bathrooms and clothes dryers to terminate outside the unvented crawlspace.
- A drainage system is required where the floor of the unvented crawlspace is located below the exterior finished grade.

3. Limit the Entry of Water Vapor into the Unvented Crawlspace

- In crawlspaces, install minimum 8-mil polyethylene across the entire ground surface. Overlap and tape all seams by 12 inches. Fasten and seal the polyethylene to the foundation walls. The polyethylene vapor barrier should be installed to a minimum of 6” above the interior final grade, as well as, 6” up the face of interior columns and piers.
- The access door and utility and exhaust pipe penetrations in the foundation should be air sealed.
- Specify a mechanical system to reduce humidity in the unvented crawlspace. One approach is to install continuously operating mechanical exhaust ventilation per code. The second approach is to have conditioned air supply sized per code to the under-floor area with an air pathway to the common area. An optional dehumidifier can be used in conjunction with either of the two approaches as needed and per plans. The specific approach selected is especially important in areas and in specific structures where radon is found to be at high levels, as builders must be careful to prevent unacceptably high levels of radon entering the living space of the house. For locations with potential high radon levels, builders may choose an HVAC approach to the crawlspace where an exhaust fan in the crawlspace draws air out of the crawlspace, and makeup air is drawn passively into the crawlspace from the rest of the house. This maintains a negative pressure in the crawlspace and thereby limits the possibility of

radon contamination in the rest of the house. However, a downside to continuous mechanical exhausting of the crawlspace is that it can result in a significant energy penalty.

B. Unvented Crawlspace Pest Control

In areas of very heavy termite probability pest control companies may require an inspection gap in the foam between the foundation and sill plate. The gap should be located below the termite shield and could be accomplished with a pressure-fit rigid foam strip slightly wider than the inspection area.

C. Unvented Crawlspace Combustion Safety

As with all interior spaces, combustion safety is important. These practices are recommended:

Specification of direct-vent combustion appliances to ensure adequate combustion air for fuel-fired appliances, if applicable [BCQC-18].
Install a carbon monoxide monitor. [BCQC-19].

D. Unvented Crawlspace Fire Safety

Fire seal penetrations in the subfloor.

Specify rigid foam insulation for the foundation walls that is an approved ignition barrier, or apply an ignition barrier over the foam insulation.

E. Unvented Crawlspace Thermal Insulation

Unvented crawlspaces are typically insulated with rigid foam insulation on the interior or exterior of perimeter walls. Foundation wall insulation applied to the interior: interior insulation leaves the foundation wall's thermal mass outside the thermal envelope. If placed on the interior, wall insulation must extend down the wall to a depth at least 2 feet below grade level vertically and/or horizontally and be rated for crawlspace and basement exposure. Rigid insulation with an aluminum facing is a good interior insulation choice. If the crawlspace wall extends less than 2 feet below grade level, then the remaining depth of insulation must be placed against the footing or horizontally along the ground at the base of the wall.

- Foundation wall insulation applied to the exterior: Application of insulation on the exterior allows the thermal mass of the foundation wall to remain inside the thermal envelope where it moderates temperature swings. Read manufacturer's recommendations for sub-surface membrane and above-grade finish requirements. Review termite inspection strip requirements with code official and treatment trade contractor.

F. Unvented Crawlspace Radon Control

Provision for a passive radon control system should be included in the crawlspace design.[10]

[10] The Environmental Protection Agency (EPA) has published county-by-county maps that identify low, moderate, and high radon risk areas. http://www.epa.gov/radon/zonemap.html

A passive soil gas stack with a collector under the polyethylene on the crawlspace floor is a common method of exhausting soil gases. The stack may be connected to an interior sub-floor drainage system via a sealed sump crock. An inline fan can be added to the stack to actively draw the gas out as standard procedure or added if testing demonstrates a need.

G. Unvented Crawlspace Concrete

Where shown on the plans, pour a concrete slab on the crawlspace floor on top of the continuous polyethylene vapor barrier [BCQC-2 & 23] to protect the barrier from being punctured or otherwise damaged when working in the crawlspace. Consult the Scope of Work for Poured Concrete Slabs Inside Residential Buildings (Basements or Crawl Spaces).

Assumed Order of Work

The assumed Order of Work for the unvented crawlspaces included in this Scope of Work is as follows:

a) Builder meets with foundation contractor to confirm 1) site location, 2) full accessibility, 3) that rough grading is complete and acceptable, 4) that all plans and details are latest edition, 5) that all approved materials they will require are on site, undamaged and securely stored, and 6) confirms temporary electrical service and water is available if needed.

b) Excavate to foundation footing grade as specified on the plan. [BCQC-2 &23] (Excavator)

c) Excavate footing trench and remove excess dirt from crawlspace and install all forming materials for footings as required. (Footing contractor/foundation contractor.)

d) Pour concrete foundation footings. (Footing or Foundation contractor)

e) Strip any concrete forms and clean up site. (Footing or Foundation contractor)

f) Install capillary break over foundation footing [BCQC-2 &23]. (Foundation contractor)

g) Construct crawlspace walls, crawlspace wall vents and interior piers as shown on plans. (Foundation contractor)

h) Grade interior of crawl space area as shown on the plans. (Footing drain contractor or concrete slab contractor).

i) Install rigid insulation to interior surface of walls as shown on plans. Extend insulation from top of foundation wall to top of footing. Mechanically fasten insulation to walls. (Foundation contractor)

j) Install interior footing and sub-floor drains if required. Locate and install any crawlspace foundation drains or sump pump drains and sump crocks per plans.

[BCQC-2 & 23nstall capillary break over foundation footing. [BCQC-2 & 23] Extend outfall of drain system to daylight or connect to exterior foundation drains. (Foundation contractor)

k) Seal all penetrations in foundation. (Performed by the contractor who created the opening.)

l) Parge exterior of foundation wall from footing to exterior finished grade. (Foundation contractor.)

m) Damp- or water-proof all exterior sub-grade parged surfaces of foundation wall. (Waterproofing contractor.)

n) Install exterior foundation drainage system and extend drain 1/8" slope per foot to daylight or drywell or sump crock, as detailed. (Draintile or foundation contractor.)

o) Add stone drainage bed and cover with filter fabric around exterior of foundation. (Excavation contractor)

p) Complete exterior backfill of foundation walls and slope grade away from the exterior of foundation wall. (Excavation contractor)

q) Install perforated radon system drainpipe in exposed floor of crawlspace as shown on the plans. (Radon contractor)

r) Install clean stone or washed gravel on floor of crawlspace per plans. (Slab or footing drain contractor.

s) Install a continuous polyethylene vapor diffusion retarder/air flow retarder of a minimum 8 mil to cover 100% of the crawlspace floor and at least 6 inches up the foundation walls and any interior columns or piers. Mechanically fasten polyethylene to the walls per plans. Overlap all horizontal polyethylene by 12 inches and seal with fiberglass mesh tape or mastic. (Slab or footing drain contractor)

(If pouring a slab in the crawlspace, see the separate concrete Scope of Work for Interior Slabs)

t) Install gasket or sealant between sill plate and top of foundation wall prior to sill plate installation. (Framing contractor)

u) Apply sealant or gasket between band joist and sill plate prior to band joist installation. (Framing contractor)

v) Complete all floor framing over crawlspace. (Framing contractor)

w) Install any ductwork, if located in the crawlspace, air seal all heating and cooling ductwork seams and connections [BCQC-15 in the crawlspace. (HVAC contractor)

x) Install and run temporary dehumidifier to maintain humidity at less than 70% to protect framing materials from excessive moisture. (Optional activity depending on moisture conditions) (HVAC contractor)

y) Finish all plumbing work in the crawlspace.(Plumber)

z) Finish all electric work in the crawlspace. (Electrical contractor)

aa) Install all other mechanical equipment and seal all ducts. [BCQC-15] Ensure that vapor retarder is installed under the air handler unit(s) if the unit(s) is to be installed in the crawlspace. (HVAC contractor)

bb) Air seal all penetrations in the band joist. (Air sealing contractor)

cc) Inspect work prior to concealment (Crew Leader, site supervisor, and local government inspector, if applicable)

dd) Insulate the band joist area around the perimeter of the crawl space. (Insulation contractor)

ee) Activate, test and adjust sump pump, HVAC and (if active) radon system. (Multiple contractors)

ff) Remove all construction debris. (Each trade is responsible for their own debris)

gg) Complete final inspection of crawl space (Crew Leader, site supervisor, and local government inspector, if applicable)

Contract Scope Language

Scope of Work for Unvented Crawlspaces

The following specific contract language is provided to supplement the trade contracts typically in place for residential construction. These trade specific items are to be inspected by the trade and the builder upon completion to assure a properly constructed and conditioned, unvented crawlspace.

Trades Involved in the Construction of an Unvented Crawlspace

Assuming that the work to be done is the same as the Assumed Order of Work Construction", the following trades may be involved in the construction of an unvented crawlspace:

1. Excavator/Grader
2. Concrete Footing Contractor
3. Foundation Contractor (Concrete contractor, bricklayer or masonry contractor)
4. Concrete Slab Contractor
5. Water-proofing or Damp-proofing contractor
6. Radon system contractor
7. Plumber
8. Termite Protection Contractor
9. Insulation Contractor
10. HVAC Contractor
11. Framing Contractor
12. Electrical Contractor
13. Clean-up Contractor

Unvented Crawlspace Specific Installation Instructions, Tolerances & Detailed Job Requirements by Trade

Excavator/Grader

Grade the interior of the crawlspace to slope as designed to drains or sump pump.
If no concrete slab is to be installed in the crawlspace, fill crawlspace area with½ to ¾ inch coarse stone (no fines) layer of gravel to floor of crawlspace to cover radon pipe, plumber's trenches, crawlspace drains, and other sump pump drainage pipes.
Grade exterior to drain away from building on all sides and ensure minimum of 4" step down at crawlspace access location.

Concrete Footing Contractor

Install all crawlspace drains or sump pump drains through the footing as required by code and/or shown on the plans.

Foundation Contractor (Concrete wall, Bricklayer or Masonry contractor)

- Ensure capillary break between footing and wall. [BCQC-2 & 23]
- No open foundation vents are installed in exterior walls. Install flood vents per local code where required.
- Ensure minimum clearance between bottom of floor joist and finished grade of crawlspace floor is 24 inches to allow for adequate access.
-

Concrete Slab Contractor

Fill crawlspace area with ½ to ¾ inch coarse stone (no fine) layer of gravel to floor of crawlspace to cover radon pipe, plumber's trenches, crawlspace drains, and other sump pump drainage pipes.
Pour concrete floor slab as called for in the plans over crawlspace floor polyethylene to prevent damage to the barrier during maintenance.
Ensure capillary break between foundation wall and slab. [BCQC-2 & 23]

Waterproofing or Damp-Proofing Contractor

Ensure all penetrations in foundation wall are water tight.
Install membrane waterproofing or spray damp-proofing on exterior crawlspace walls as per plans.

Radon System Contractor

- For radon resistance, install perforated drainpipe on exposed floor of crawlspace and connect to a plastic tee fitting located just below the level of the polyethylene vapor retarder.
- Connect to a vertical 3 or 4 inch plastic soil gas ventilation stack pipe running through an interior wall from the crawlspace to through the roof per plans.
- Extend pipe 12 inches minimum above roof and 10 feet from openings into closed spaces of the building.
- If required after occupancy, install an active radon mitigation system by attaching an electric fan to the plastic pipe in the attic and mechanically exhaust any radon gas to the outside.

Plumber

Complete all plumbing work including sump pump, drains and dehumidifier drains, if applicable. All water must drain outside to daylight or outside using a sump pump.

Sump pumps

Excavate sump locations and protect from collapse prior to installation of sump pit and pump.

Activate, test and adjust sump pump.

Install water alarm to monitor any water accumulation.

Drains

Install crawlspace floor drains per plans. Gutter drains and foundation drain (interior or exterior) pipes must extend to daylight and terminate with ¼" rodent screening and include an accessible drain backflow valve.

Terminate water heater drains, and temperature/pressure relief pipes to exterior of crawlspace or to interior pump that discharges to exterior or to other plumbing drains.

Install a water alarm to inform the build up of water in the crawlspace if shown on the plans.

Termite Protection Contractor

- For chemical termite protection, treat the soil inside and around the exterior perimeter of the crawlspace. Treat soil only after all excavation, backfill, and final grading has been completed so no disturbance of the treated soil can occur.
- For termite bait systems, install bait trap locations outside the crawlspace after all final grading work has been completed.
- For physical termite protection systems, provide all barrier materials and coordinate with framing contractor to install barriers below lowest level of any wood framing (sill plate areas and piers).

Insulation Contractor

Install a continuous 8 mil (minimum) polyethylene vapor retarder to cover 100% of the crawlspace floor.

Install the polyethylene on the inside of the foundation wall and mechanically fasten and seal it to the wall per plans.

Extend the polyethylene up any interior columns at least 6 inches above the crawlspace floor, mechanically fasten the top of the polyethylene and seal with fiberglass mesh tape or mastic.

Overlap all polyethylene by 12 inches and seal with fiberglass mesh tape or mastic.

Seal polyethylene at all points of penetration by pipes, wires, piers, or posts. [BCQC-16]

Insulate the crawlspace walls by installing code approved rigid insulation as shown on the plans to either,

The interior of foundation wall. Interior insulation requires a code approved fire-rated covering. Install from the top of the interior foundation footing to top of foundation wall. Fasteners shall be installed in accordance with the approved plans.

- The exterior of foundation wall. Exterior rigid insulation shall be covered and finished for protection against damage.

- Per plans, leave a 3-inch termite inspection gap between the top of the insulation and the top of the masonry or concrete wall.

HVAC Contractor

If required by the builder due to site moisture conditions, install a temporary dehumidifier to maintain targets of <70% relative humidity or <15% wood moisture content in the crawlspace. The dehumidifier condensate must be drained or pumped to the outside of the crawlspace.
Install ducts and HVAC equipment in conditioned space as shown on the plans.
Install any ductwork located in the crawlspace.
Air seal all ductwork seams, boots, and connections with UL181 tape or approved mastic. [BCQC-15]

- Terminate A/C condensate drains to exterior of crawlspace or interior pump that discharges to exterior or to other plumbing drain.
- Install any fuel fired furnaces, water heaters or other appliance using a direct vent or two pipe design so that all air for combustion is piped directly from outside to the appliance and all combustion exhaust gases are piped directly from the appliance to outside. [BCQC-18]
- Activate, test and adjust HVAC equipment and (if active) radon system.

Per plans and local codes, choose either approach 1 or 2 below:

1. Unvented Crawlspace Conditioning:
Actively condition crawlspace per code.

2. Exhaust System in Unvented Crawlspace:
Exhaust moisture and other contaminants from crawlspace using a continuous operation exhaust fan sized per code.

Below is an optional third approach that may be used in conjunction with either approach 1 or 2 per site requirements and plans

3. Dehumidification of Unvented Crawlspace (Optional addition per plans to one of the previous HVAC approaches)

Framing Contractor

- Ensure that roof rainwater and other runoff does not enter the crawlspace during construction.
- Ensure eave overhangs are constructed per plans.
- Crawlspace access panels or doors must be weather stripped/air sealed. Access doors should be 24 inches high and 30 inches wide and at least 4” inches higher than the exterior grade.

- Install gasket or sealant between sill plate and top of foundation wall prior to sill plate installation.
- Seal exterior wall penetrations and mating surfaces at top and bottom of sill plate and at top and bottom of band joist. [BCQC-16]

Electrical Contractor

Finish all electric work in the crawlspace, including at least one permanently wired, non-switched GFCI protected outlet in proximity to the sump crock.
Provide a dedicated non-switched GFCI protected outlet to any permanent electric-powered equipment in crawlspace such as a dehumidifier or an exhaust fan.
Install optional monitoring system to inform the homeowner of relative humidity levels in the crawlspace per plans.
Install an electrical junction box in the attic space in proximity to the passive radon exhaust stack.

Clean up Contractor

- Ensure all drains are clear and water is not standing in sump pit.
- Keep crawlspace door closed when not in use.
- Ensure a sign is posted to notify all accessing the crawlspace of the system components maintaining the integrity of the system and to remind them to close and latch the access door on leaving.
- Ensure that the integrity of the vapor retarder is maintained or repaired until final completion and occupancy by the homeowner.
- The contractor shall remove all nails used for hanging cords, hoses and temporary heating enclosures in the crawlspace.
- Clean up any excess debris in the crawlspace and place in trash dumpster at the end of the work day. (Task to each trade contractor.)
- Crawlspace to be left clean of all waste and debris when final occupancy occurs.
- Slab floor is to be broom clean.

Inspection Checklists

Unvented Crawlspaces

NOTE: No one Job Ready checklist is required for Unvented Crawlspaces because crawlspaces are constructed by multiple trades. A builder's documented QMS will already have a Job Ready inspection for each of the individual trades that need to include the specific Unvented Crawlspace responsibilities. In addition, a Job Complete Checklist is needed for each of these trades' responsibilities. A generic Job Ready Checklist form is included here as an example.

In this Scope of Work, the Job Complete inspection form is subdivided by trade to include only the items that each trade would typically be expected to perform specific to the construction of an unvented crawlspace. All other residential construction items

have been excluded from the inspection forms in this scope, but each of the trades' standard Scope of Work should address all aspects of the project pertaining to that trade.

(Insert Builder/Trade Company Name & Logo)

All Contractors

Unvented Crawlspace Job Ready Checklist

All items must be inspected and signed off by builder and trade before trade begins work [BCQC1]

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader	**Trade Super**	**Builder**	**Explain Needed Corrections List Date Corrected**
		OK	**OK**	**OK/NA**	
Describe Current Hotspot: Completely filling out checklist forms by site crew		❑	❑	❑	
1.	Job sign and address is posted and visible	❑	❑	❑	
2.	Site access acceptable	❑	❑	❑	
3.	All safety equipment on site and ready to use	❑	❑	❑	
4.	Add trade specific customized items	❑	❑	❑	
		❑	❑	❑	
		❑	❑	❑	
Additional Correction Items:					
			❑	❑	
			❑	❑	
			❑	❑	

Sign here to acknowledge that all above items have been completed	**Trade Signature:**	**Date:**
	Builder Signature:	**Date:**

(Insert Builder/Trade Company Name & Logo)

All Contractors

Unvented Crawlspace Job Complete Checklist

Upon completion of work, the trade and builder must verify proper installation and sign off on all items as acceptable. Correction items needing correction must be re-inspected and confirmed. [BCQC-1]

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader	**Trade Super**	**Builder**	**Explain Needed Corrections List Date Corrected**
		OK	**OK**	**OK/NA**	
EXCAVATION CONTRACTOR: Name/Date_____					
Describe Current Excavation Hotspot:		❑	❑	❑	
1.	Foundation drains are complete per plans and free-flowing [BCQC-23]	❑	❑	❑	
2.	Crawlspace interior is backfilled and graded with a final grade per plans with positive exterior drainage on all 4 sides of building [BCQC-23]	❑	❑	❑	
3.	Interior of crawlspace is graded per plan with positive drainage toward any installed drains or to sump crock[BCQC-23]	❑	❑	❑	
4.	Final grade at crawlspace access location shows 4" step down	❑	❑	❑	
CONCRETE FOOTING CONTRACTOR: Name/Date_____					
Describe Current Footing Hotspot:		❑	❑	❑	
1.	All crawlspace drains or sump pump drains are piped through the footing or wall as shown on plans.	❑	❑	❑	
Foundation CONTRACTOR: Name/Date_____					
		❑	❑	❑	
1.	Flood vents are installed per code where required	❑	❑	❑	
2.	All walls complete per plans including all anchor bolts or tie-down straps properly located	❑	❑	❑	
3.	Wall height is sufficient for required minimum clearance of 24" from finished crawl surface to bottom of framing	❑	❑	❑	
4.	Mechanical openings constructed per plans	❑	❑	❑	
5.	No operable ambient air vents are installed.	❑	❑	❑	
Describe the Current Concrete Wall Hotspot:		❑	❑	❑	
1.	All walls complete per plans with properly located	❑	❑	❑	

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader OK	Trade Super OK	Builder OK/NA	Explain Needed Corrections List Date Corrected
	anchor bolts or tie downs.				
2.	Wall height sufficient for required min. 24" clearance in crawlspace	❑	❑	❑	
3.	All forms, bracing, and concrete materials have been removed or recycled	❑	❑	❑	
4.	No wall vents installed; mechanical openings per plans	❑	❑	❑	
CONCRETE SLAB CONTRACTOR: Name/Date_____					
Describe Current Concrete Slab Hotspot:		❑	❑	❑	
1.	Capillary break is installed between slab and all walls and piers [BCQC-23]	❑	❑	❑	
2.	Concrete is finished with positive drainage to all sumps and/or drains [BCQC-23]	❑	❑	❑	
3.	Expansion joint is installed between slab and all walls and piers	❑	❑	❑	
WATER PROOFING/DAMPPROOFING CONTRACTOR Name/Date_____					
Describe Current Damp-proofing Hotspot:		❑	❑	❑	
1.	All wall penetrations are watertight [BCQC-23]	❑	❑	❑	
2.	Membrane waterproofing or spray damp-proofing is installed per plans on exterior crawlspace wall [BCQC-23]				
RADON SYSTEM CONTRACTOR/Draintile Contractor/Date_____					
Describe Current Radon System Hotspot:		❑	❑	❑	
1.	Radon collection piping installed in the coarse aggregate per plans	❑	❑	❑	
2.	Radon passive stack is installed through roof surface	❑	❑	❑	
3.	In-line fan installed and tested (if active system) per plan or if needed per radon testing.	❑	❑	❑	
4.	Floor drain(s) is complete and free flowing [BCQC-23]	❑	❑	❑	
PLUMBING CONTRACTOR Name/Date_____					
Describe Current Plumbing Hotspot:		❑	❑	❑	
1.	Sump discharges to daylight [BCQC-23]	❑	❑	❑	
2.	All drainage to exterior of crawl, (i.e. sump,	❑	❑	❑	

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader	Trade Super	Builder	Explain Needed Corrections List Date Corrected
		OK	OK	OK/NA	
	condensate, water heater temp/pressure relief valve, etc.) and discharge pipes covered with insect screen				
3.	Sump pump backflow valve is in place and operational	❑	❑	❑	
4.	Install water alarm to monitor status of water level in the sump pit [BCQC-23]	❑	❑	❑	
TERMITE PROTECTION Contractor: Name/Date_____					
Describe Current Termite Protection Hotspot:		❑	❑	❑	
1.	Soil is treated inside and outside crawlspace or bait traps are installed per plans per plans	❑	❑	❑	
2.	Termite barriers are in place all framing members that contact foundation/slab/piers/columns.	❑	❑	❑	
INSULATION Contractor: Name/Date_____					
Describe Current Insulation Hotspot:		❑	❑	❑	
1.	Seal all penetrations in band joist and floor system	❑	❑	❑	
2.	Continuous vapor retarder is installed, lapped at least 12", taped, and sealed over 100% of crawl surface and at all pipes and penetrations [BCQC-23]	❑	❑	❑	
3.	Vapor retarder laps a minimum of 6" on all interior piers and posts [BCQC-23]	❑	❑	❑	
4.	Vapor retarder is mechanically attached to top of wall [BCQC-23]	❑	❑	❑	
5.	All insulation on band joists and crawlspace walls, is complete per plans [BCQC-16]	❑	❑	❑	
6.	All crawlspace wall insulation is installed and fastened per manufacturer's instructions [BCQC-16]	❑	❑	❑	
7.	Rigid interior insulation taped and sealed per plans [BCQC-23]	❑	❑	❑	
8.	Exposed interior insulation has a code approved ignition barrier or surface	❑	❑	❑	
9.	Inspection gap at top of foundation has been accommodated if required per plans	❑	❑	❑	
10.	Exterior rigid insulation is installed and protected per approved plans [BCQC-16]	❑	❑	❑	
HVAC CONTRACTOR: Name/Date_____					

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader OK	Trade Super OK	Builder OK/NA	Explain Needed Corrections List Date Corrected
Describe Current HVAC Hotspot:		❑	❑	❑	
1.	Temporary humidifier is disconnected and removed	❑	❑	❑	
2.	All duct joints are sealed with UL 181 tape or approved mastic [BCQC-15]	❑	❑	❑	
3.	All ductwork in crawlspace is sealed and pressure tested [BCQC-15]	❑	❑	❑	
4.	All ducts and returns are insulated per plans [BCQC-15]	❑	❑	❑	
5.	All A/C condensate drains terminate outside crawlspace	❑	❑	❑	
6.	All appliances located in crawlspace are sealed combustion or directly vented to exterior [BCQC-18]	❑	❑	❑	
8.	Check **Option 1** if applicable: ___ Crawlspace conditioning per code including supply air to crawl per plans, humidistat installed in crawlspace, backflow damper installed per plans, and return in crawlspace **OR** Check **Option 2** if applicable: ___ Exhaust only crawlspace conditioning is installed with continuously operating fan to exhaust crawlspace, direct outside air intake or adequate exhaust system supply from conditioned space, and alarm to indicate any fan interruption.	❑	❑	❑	
9.	Per plans, crawlspace is dehumidified with dehumidifier located in crawlspace, condensate discharged to exterior of crawlspace, alarm to indicate any dehumidification interruption	❑	❑	❑	
FRAMING CONTRACTOR: Name/Date_____					
Describe Current Framing Hotspot:		❑	❑	❑	
1.	Overhangs and roof overhangs direct roof rainwater runoff away from crawlspace [BCQC-23]	❑	❑	❑	
2.	Sealed crawlspace access door with spring hinges is a minimum of 24”x30”, installed with latch, and at least 4” higher than exterior grade	❑	❑	❑	
3.	Install sill sealer under all sill plates [BCQC-16]	❑	❑	❑	
ELECTRICAL CONTRACTOR:					

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader	**Trade Super**	**Builder**	**Explain Needed Corrections List Date Corrected**
		OK	**OK**	**OK/NA**	
Name/Date_____					
Describe Current Electrical Hotspot:		❑	❑	❑	
1.	Non-switched GFCIs located in attic near radon riser and in crawlspace near all equipment	❑	❑	❑	
2.	Wiring to humidity monitor and water monitor complete and operable	❑	❑	❑	
3.	Install crawlspace lighting and service receptacles per plans with light switch near access door.	❑	❑	❑	
CLEAN UP CONTRACTOR: Name/Date_____					
Describe Current Clean-up Hotspot:		❑	❑	❑	
1.	All exterior drains and sump drains clear and free flowing before homeowner move-in [BCQC-23]	❑	❑	❑	
2.	Polyethylene in crawlspace is continuous and any holes or tears are repaired [BCQC-23]	❑	❑	❑	
3.	Sign posted to warn to keep crawl door latched and vapor retarder intact throughout life of structure	❑	❑	❑	
4.	Crawlspace broom clean (if slab floor) and free of all trash, temporary nails in framing, temporary polyethylene, and debris before homeowner move-in	❑	❑	❑	
5.	18" clearance between mulch and landscaping and foundation wall. [BCQC-23]	❑	❑	❑	
Additional Correction Items:					
			❑	❑	
			❑	❑	
			❑	❑	

Sign here to acknowledge that all above items have been completed	**Builder Signature:** _____	**Date:**

Vented Crawlspaces

Introduction

Vented crawlspaces are a quick and economical approach to a level and solid foundation in many climates. Once a builder has decided to build a vented crawlspace, it is important to build it properly to assure durability and the quality of indoor air. This scope is designed to provide guidance to those builders and their trade contractors who decide to build traditional vented crawlspaces.

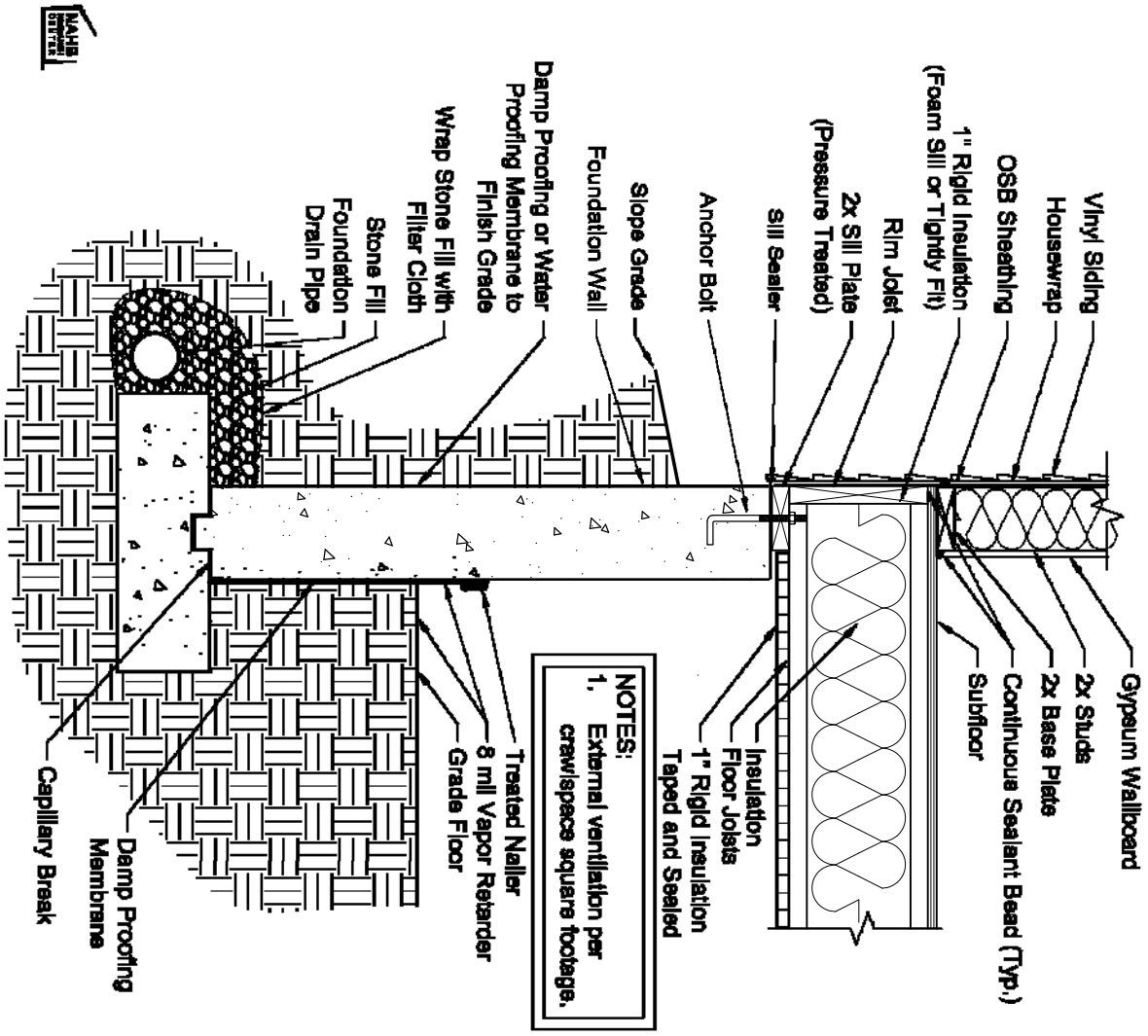
Purpose of this High Performance Scope of Work
A High Performance Scope of Work for constructing vented crawlspaces is designed to achieve the following:

Define the design and construction specifications that must be addressed in order to construct a high performance crawlspace including: thermal insulation, equipment and duct location, moisture management, pest control, combustion safety, fire safety, and radon control.

- Proper design, proper definition of required design implementation, and an effective method of determining design compliance are keys to achieving high performance home results.
- Defining the expected work of several contractors such that roles and responsibilities of contractor and builder are clearly understood and both may be accountable for required performance. These are included as sections of each contractor's Scope of Work.
- Defining the conditions required for commencement of each separate contractor's work (Job Ready Checklists).
- Defining the conditions required for acceptance of each separate contractor's completed work (Job Complete Checklist).

Scope Content
A High Performance Scope of Work for the vented crawlspace work is especially challenging given the large number of trades involved and the unlikely scenario where all required work will be included as a part of a single trade contract. This crawlspace Scope of Work covers the following residential installation: a vented crawlspace including thermal insulation, equipment and duct location, moisture management, pest control, combustion safety, fire safety, and radon control.

Any high performance home Scope of Work assumes certain field activities and an order of work. While these assumptions are not an integral part of the builder/trade contractor legal contract, these assumptions can make a useful training aide and become the basis for a field manager's checklist. (See Assumed order of work.)


Foundation Section - Unconditioned (Vented) Crawlspace
Vinyl Siding
Housewrap
OSB Sheathing
1" Rigid Insulation (Foam Sill or Tightly Fit)
Rim Joist
2x Sill Plate (Pressure Treated)
Sill Sealer
Anchor Bolt
Slope Grade
Foundation Wall
Damp Proofing or Water Proofing Membrane to Finish Grade
Wrap Stone Fill with Filter Cloth
Stone Fill
Foundation Drain Pipe
Capillary Break
Damp Proofing Membrane
Grade Floor
8 mil Vapor Retarder
Treated Nailer
1" Rigid Insulation Taped and Sealed
Floor Joists
Insulation
Subfloor
Continuous Sealant Bead (Typ.)
2x Base Plate
2x Studs
Gypsum Wallboard
NOTES:
1. External ventilation per crawlspace square footage.

Builders Challenge

The Builders Challenge certification program is used to confirm that certified homes are designed to achieve at least a minimum level of energy performance that exceeds current efficiency requirements by 30% and to document their as-built performance levels, even including net-zero energy homes (ZEH). In addition to the energy performance requirement of the Builders Challenge, there is a set of Builders Challenge Quality Criteria (BCQC) representing high performance home best practices. The complete set of BCQC requirements and the Builders Challenge Quality Criteria Support Document can be found at: Builders Challenge Quality Criteria Support Document.

A builder may also use the Scope of Work to verify that the Builders Challenge criteria relevant to each trade contractor have or have not been completed by each of their trade partners. Builders Challenge items are indicated throughout the scopes of work and checklists. They are denoted by a gray highlight. In addition, a note in italics accompanies the provision noting which Builders Challenge Quality Criteria the item addresses. For example, *[BCQC-2]* stands for Builders Challenge Quality Criteria item number 2.

Design and Specification Prerequisites

Vented Crawlspaces

A. Vented Crawlspace Moisture Management [BCQC-2][11]

A vented crawlspace must address several types of moisture management issues. Prolonged moisture in the crawlspace may cause structural decay and contribute to human health and comfort problems. First any bulk water entering into the vented crawlspace must be discharged to the exterior of the house and away from the crawlspace. Second, any moisture occurring in the crawlspace must be effectively directed out of the crawlspace. Third, the movement of water vapor must be limited to the extent possible within the crawlspace.

The final area of water management is the humidity in the crawlspace. In areas with high humidity, moisture is carried into the crawlspace through the crawlspace wall vents. When this warm moist air reaches structural framing cooled from air conditioning use, the vapor condenses out of the air and becomes water in the floor system that can lead to wood rot and degradation of the thermal performance of the insulation.

1. Shed/Keep Bulk Moisture from the Foundation

- Ensure a roof rainwater runoff system to direct water away from the house with roof drainage directed at least 5 feet beyond the building

[11] Builders Challenge Quality Criteria 2 requires consideration of water management in the design phase and BCQC-23 requires water management field verification. Water management per BCQC-2 & 23 is addressed in all of Section A.

- Ensure proper site engineering and landscaping to maintain adequate site drainage. Local groundwater tables at their maximum elevation should be below the lowest excavated site foundations levels.
- Create site grading and landscaping that directs ground surface water away from the house. Grading and landscaping should be planned for movement of building run-off away from the home and its' foundation, with a surface grade of at least 5% maintained for at least 10 feet around and away from the entire structure, or otherwise mitigate with alternative foundation drainage systems such as swales, french drains, or storm drains per plans.
- Plantings should be held back as much at least 18 inches from the finished structure, with any supporting irrigation directed away from the finished structure. Plantings may be selected to shade the foundation edge, especially on the southwest corner of the structure. Choosing native plantings results in less irrigation and less chance for irrigation water to create a moisture problem in the house. Water absorbing ground cover—mulch or bark chips, for example—should be thinned to no more than 2 inches for the first 18 inches from the finished structure to reduce moisture near the foundation.
- Use interior and/or exterior foundation drains and foundation damp-proofing or water-proofing to protect the structure from sub-surface water.
- Ensure that an exterior crawlspace access door is protected from roof runoff and is at least 4" higher than the exterior soil grade and made of a non-corroding material, especially in coastal communities exposed to salt air.

2. Restricting and Removing Excess Moisture from the Crawlspace

- Assure that all appliance discharge pipes and exhausts from kitchens, bathrooms and clothes dryers terminate outside the crawlspace
- Foundation drainage is needed for crawlspaces.
- Special attention is required where the slab or the floor of the crawlspace is located below grade.
- Foundation drains with backflow valves or sump pumps must be provided to remove liquid water from the crawlspace if necessary

3. Control Water Vapor within the Crawlspace

- One source of moisture problems in crawlspaces comes from the combination of moist air and cold temperatures. Air in crawlspaces may be moist due to the proximity of wet soil, moisture in outside air, and moisture laden air leaks from the house.
- In combination, the vented crawlspace ground surface systems should provide a continuous high quality, water resistant layer capable of resisting both capillary and hydrostatic water penetration.

- In crawlspaces, install a minimum 8-mil polyethylene across the entire ground surface. Overlap and tape all seams by 12 inches. Seal the polyethylene at least 6 inches up the walls and any interior piers or to a height equal to the exterior ground level. Pressure treated wood strapping can be used to secure the polyethylene to the wall.
- To improve durability, pour a minimum 2-inch concrete slab over the polyethylene.

- Install specifically designed pressure release "flood vents" required in flood prone areas.
- If necessary, specify a mechanical ventilation system to reduce humidity in the vented crawlspace.

B. Vented Crawlspace Pest Control

Termite shields can be installed as an entry prevention method against termites
Termite bait traps and or soil treatments can be used as well.

C. Vented Crawlspace Combustion Safety

The issue of combustion safety involves what combustion is occurring, that the combustion have adequate fresh air to provide oxygen needed for combustion, and if the occupants have any warning of a combustion problem in a closed space "hidden" from the occupant's normal day-to-day activities.

One way to assure combustion safety in the crawlspace is to avoid any intentional combustion activity. This is accomplished by not locating any combustion HVAC and domestic hot water systems in crawlspace.

If installing combustion equipment in the crawlspace:

- Warn the occupants to avoid tightly closing the crawlspace vents;
- Install a smoke detector and a fire detector (code required or not) to warn occupants of any smoke or fire in the crawlspace; and
- Install a carbon monoxide detector [BCQC-19] (code required or not) to detect carbon monoxide build up caused by pilot lights or other flames being starved of combustion air.

D. Vented Crawlspace Fire Safety

Exposed surfaces in vented crawlspaces must be ASTM E 84 Class C materials.
Specify air sealing of all penetrations in the subfloor with non-porous materials and fire blocking to deny the fire needed fresh air and reduce the chimney effect in the event of any fire.
Specify the proper fire-rating of any exposed materials, especially foam insulation, insulation facing, and any paper products, to reduce the flame-spread possibilities in the crawlspace.

E. Floor Insulation in Vented Crawlspaces

Vented crawlspaces are typically insulated in the floor above the crawlspace. Floor insulation is placed between the floor joists. It is important that there be no air gap between the subfloor and the top surface of the insulation. Floor insulation, rather than moderating the conditions within the crawlspace, is designed to isolate the fully conditioned space of the house from that of the crawlspace, while also serving to minimize the temperature differences between the crawlspace air and the exposed bottom surface of the insulated floor. A well-insulated floor results in little or no condensation on the underside of the floor, thereby limiting the problems or mold and rotting of the floor material itself. Rigid foam insulation, taped and sealed, should be added to bottom of the floor joists to reduce thermal bridging.

F. Vented Crawlspace Radon Control

In areas of high radon concentrations, builders may wish to include inexpensive radon control measures in a vented crawlspace. The Environmental Protection Agency (EPA) has published county-by-county maps that identify low, moderate, and high radon risk areas. http://www.epa.gov/radon/zonemap.html

- One measure recommended in risk areas and also recommended by the EPA to control potentially high radon levels and other soil gasses, is a passive soil gas stack connected to a perforated drain pipe embedded in the gravel under the slab, basement floor, or crawlspace ground cover. The stack may also be attached to a perforated pipe loop or mat, and is sometimes integrated into the sump pit and the interior perimeter drainage system, where installed.
- In areas where radon is a risk or where the local residential code requires control of radon or other soil gases, houses with a vented crawlspace foundation should be tested and monitored. If testing indicates the house has unacceptable radon levels, a fan can be added to the passive radon exhaust stack with minimal time and expense to actively draw soil gas away from the house.

G. Vented Crawlspace Concrete

Where shown on the plans, pour a concrete slab on the crawlspace floor on top of the continuous polyethylene vapor barrier to protect the barrier from being punctured or otherwise damaged when working in the crawlspace. Consult the Scope of Work for Interior Slabs for concrete slab construction details.

Assumed Order of Work

The assumed Order of Work for the vented crawlspaces included in this Scope of Work is as follows:

a) Builder meets with foundation contractor to confirm 1) site location, 2) full accessibility, 3) that rough grading is complete and acceptable, 4) that all plans and details are latest edition, 5) that all materials they will require are on site,

undamaged and securely stored, and 6) confirms temporary electrical service and water is available if needed.

b) Excavate to foundation footing grade as specified on the plan. [BCQC-2 &23] (Excavator)

c) Excavate footing trench and remove excess dirt from crawlspace and install all forming materials for footings as required. (Footing contractor/foundation contractor.)

d) Pour concrete foundation footings. (Footing or Foundation contractor)

e) Strip any concrete forms and clean up site. (Footing or Foundation contractor)

f) Install capillary break over foundation footing [BCQC-2 &23]. (Foundation contractor)

g) Construct crawlspace walls and interior piers as shown on plans. (Foundation contractor)

h) Grade interior of crawl space area as shown on the plans. (Footing drain contractor or concrete slab contractor).

i) Install interior footing and sub-floor drains if required. Locate and install any crawlspace foundation drains or sump pump drains and sump crocks per plans. [BCQC-2 & 23nstall capillary break over foundation footing. [BCQC-2 & 23] Extend outfall of drain system to daylight or connect to exterior foundation drains. (Foundation contractor)

j) Seal all penetrations in foundation. (Performed by the contractor who created the opening.)

k) Parge exterior of foundation wall from footing to exterior finished grade. (Foundation contractor.)

l) Damp- or water-proof all exterior sub-grade parged surfaces of foundation wall. (Waterproofing contractor.)

m) Install exterior foundation drainage system and extend drain to daylight or drywell or sump crock, as detailed. (Draintile or foundation contractor.)

n) Add stone drainage bed and cover with filter fabric around exterior of foundation. (Excavation contractor)

o) Complete exterior backfill of foundation walls and slope grade away from the exterior of foundation wall. (Excavation contractor)

p) In high radon risk areas, install perforated radon system drainpipe in exposed floor of crawlspace as shown on the plans. (Radon contractor)

q) Install clean stone or washed gravel on floor of crawlspace per plans. (Slab or footing drain contractor.

r) Install a continuous polyethylene vapor diffusion retarder/air flow retarder of a minimum 8 mil to cover 100% of the crawlspace floor and at least 6 inches up the foundation walls and any interior columns or piers. Mechanically fasten

polyethylene to the walls per plans. Overlap all horizontal polyethylene by 12 inches and seal with fiberglass mesh tape or mastic. (Slab or footing drain contractor)

(If pouring a slab in the crawlspace, see the separate concrete Scope of Work for Interior Slabs)

s) Install gasket or sealant between sill plate and top of foundation wall prior to sill plate installation. (Framing contractor)

t) Apply sealant or gasket between band joist and sill plate prior to band joist installation and complete floor framing. (Framing contractor)

u) Complete all floor framing over crawlspace. (Framing contractor)

v) Install any ductwork, if located in the crawlspace, air seal all heating and cooling ductwork seams and connections in the crawlspace. (HVAC contractor)

w) Terminate water heater drains, temperature/pressure relief pipes, clothes dryer vents, kitchen exhaust, bathroom exhaust, [BCQC-12,13,14] HVAC condensate drains outside the crawlspace. (Various contractors)

x) Install and close the exterior crawlspace access door(s). (Framing contractor)

y) Install and run temporary dehumidifier to maintain humidity at less than 70% to protect framing materials from excessive moisture. (Optional activity depending on moisture conditions) (HVAC contractor)

z) Finish all plumbing work in the crawlspace.(Plumber)

aa) Finish all electric work in the crawlspace. (Electrical contractor)

bb) Install all other mechanical equipment and seal all ducts. [BCQC-15] Ensure that vapor retarder is installed under the air handler unit(s) if the unit(s) is to be installed in the crawlspace. (HVAC contractor)

cc) Inspect work prior to concealment (Crew Leader, site supervisor, and local government inspector, if applicable)

dd) Air seal all penetrations in the subfloor and band joist and insulate the band joist area [BCQC-16]. (Insulation contractor)

ee) Install the floor insulation between floor joists with no airspace between flooring (OSB/Plywood) and the insulation. [BCQC-16]. (Insulation contractor)

ff) Activate, test and adjust sump pump, HVAC and (if active) radon system. (Multiple contractors)

gg) Provide reinforcing material for the ground cover along the paths to the air handler unit and any other equipment that will be serviced as needed depending on the thickness and durability of the ground cover. (Insulation contractor)

hh) Install a laminated sign inside the crawlspace access door to remind those entering to keep the access door closed and keep the vapor retarder intact. (Insulation contractor)

ii) Remove all construction debris. (Each trade is responsible for their own debris)

jj) Complete final inspection of crawl space (Crew Leader, site supervisor, and local government inspector, if applicable)

Contract Scope Language

Scope of Work for Vented Crawlspaces

The following specific contract language is provided to supplement the trade contracts typically in place for residential construction. These trade specific items are to be inspected by the trade and the builder upon completion to assure a properly constructed and conditioned unvented crawlspace.

Trades Involved in the Construction of a Vented Crawlspace

Assuming that the work to be done is the same as the "Agreed Upon Order of Construction" shown below, the following trades may be involved in the construction of a unvented crawlspace:

1. Excavator/Grader
2. Concrete Footing Contractor
3. Masonry Contractor (Concrete wall, Bricklayer or Masonry Contractor)
4. Concrete Slab Contractor
5. Water-proofing or Damp-proofing contractor
6. Radon system contractor
7. Plumber
8. Termite Protection Contractor
9. Insulation Contractor
10. HVAC Contractor
11. Framing Contractor
12. Electrical Contractor
13. Clean up Contractor

Vented Crawlspace Specific Installation Instructions, Tolerances & Detailed Job Requirements by Trade

Excavator/Grader

Where possible, ensure that the interior finished grade of crawlspace floor is equal to or higher than the exterior grade.
Grade the interior of the crawlspace to slope to drains or sump pump.
If no concrete slab is to be installed in the crawlspace, fill crawlspace area with ½ to ¾ inch coarse stone (no fine) layer of gravel to floor of crawlspace to cover radon pipe, plumber's trenches, crawlspace drains, and other sump pump drainage pipes.
Complete final grading to ensure a 4" step down from the crawlspace access to the finished grade.

Concrete Footing Contractor

- Install all crawlspace drains or sump pump drains through the wall or footing as required per code and/or shown on the plans.

Masonry Contractor (Concrete wall, Bricklayer or Masonry Contractor)
Install capillary break as shown on the plans. [BCQC-2]

Construct and reinforce all masonry crawlspace walls and interior support piers shown on the plans.
Install and secure any metal posts as shown on the plans.
Install all foundation vents in locations as shown on the plans.
Install flood vents per local code where required.
Ensure minimum between bottom of floor joist and finished grade of crawlspace floor is 24 inches to allow for adequate access.

Concrete Slab Contractor

- Fill crawlspace area with½ to ¾ inch coarse stone (no fines) layer of gravel to floor of crawlspace to cover radon pipe, plumber's trenches, crawlspace drains, and other sump pump drainage pipes.
- Install capillary break as shown on the plans. [BCQC-2]
- Pour concrete floor slab if called for in the plans over crawlspace floor polyethylene to prevent damage to the barrier during maintenance.

Waterproofing or Damp-Proofing Contractor

Ensure all penetrations in foundation wall are water tight. [BCQC-2]
Install membrane waterproofing or spray damp-proofing on exterior crawlspace walls as per plans. [BCQC-2]

Radon System Contractor

(In high risk radon areas) For radon resistance install perforated drainpipe on exposed floor of crawlspace and connect to a plastic tee fitting located just below the level of the polyethylene vapor retarder.

- Connect to a vertical 3 or 4 inch plastic soil gas ventilation stack pipe running through an interior wall from the crawlspace to through the roof.
- Extend pipe 12 inches minimum above roof and 10 feet from openings into closed spaces of the building.
- If required after radon testing, install an active radon mitigation system by attaching an electric fan to the plastic pipe in the attic and mechanically exhaust any radon gas to the outside.

Plumber

- Finish all plumbing work including sump pump, drains and dehumidifier drains if applicable. All water must drain outside to daylight or outside using a sump pump.

Sump pumps

- Excavate sump locations and protect from collapse prior to installation of sump pit and pump.
- Activate, test and adjust sump pump.
- Install water alarm to monitor any water accumulation.

Drains

- Install crawlspace floor drains. Gutter drains and foundation drain (interior or exterior) pipes must extend to daylight and terminate with ¼" rodent screening and include an accessible drain backflow valve.
- Install a water alarm to inform the build up water in the crawlspace if shown on the plans.
- Terminate water heater drains, and temperature/pressure relief pipes to exterior of crawlspace or to interior pump that discharges to exterior or to other plumbing drains.

Termite Protection Contractor

For chemical termite protection, treat the soil inside and around the exterior perimeter of the crawlspace. Treat soil only after all excavation, backfill, and final grading has been completed so no disturbance of the treated soil can occur.
For termite bait systems, install bait trap locations outside the crawlspace after all final grading work has been completed.
For physical termite protection systems, provide all barrier materials and coordinate with framing contractor to install barriers below lowest level of any wood framing (sill plate areas and piers).

Insulation Contractor

Install a continuous 8 mil (minimum) polyethylene vapor retarder to cover 100% of the crawlspace floor. [BCQC-2]
Install the polyethylene on the inside of the foundation wall and mechanically fasten and seal it to the wall per plans.
Extend the polyethylene up any interior columns at least 6 inches above the crawlspace floor, mechanically fasten the top of the polyethylene and seal with fiberglass mesh tape or mastic
Overlap all polyethylene by 12 inches and seal with fiberglass mesh tape or mastic.
Seal polyethylene at all points of penetration by pipes, wires, piers, or posts. [BCQC-16]
Install cavity floor insulation in the floor over the crawlspace. Install insulation between floor joists with no airspace between the top of the insulation and the floor surface (OSB/Plywood). [BCQC-16]
Insulate the floor over the crawlspace with rigid insulation taped and sealed, installed to the bottom of floor joists.

HVAC Contractor

- Terminate A/C condensate drains to exterior of crawlspace or interior pump that discharges to exterior or to other plumbing drain.
- Activate, test and adjust sump pump, HVAC and (if active) radon system.
- Install mechanical ventilation fan to circulate crawlspace air as shown on the plans.

Framing Contractor

Ensure that roof and other runoff does not enter the crawlspace during construction.

Ensure eave overhangs are adequate to shelter ground nearest foundation wall and that adequate gutters and downspouts (with extensions) are used to ensure adequate removal of rainfall runoff from foundation area.
Install access doors 24 inches high and 30 inches wide and at least 4 inches higher than the exterior grade.
Air seal all penetrations in the subfloor and band joist. [BCQC-15]
Seal at top and bottom of sill plate and at top and bottom of band joist. [BCQC-16]

Electrical Contractor

- Finish all electric work in the crawlspace, including at least one permanently wired, non-switched GFCI protected outlet.
- Provide a dedicated non-switched GFCI protected outlet to any permanent electric-powered equipment in crawlspace such as HVAC equipment, dehumidifier, water alarm, or an exhaust fan. Provide wiring for water alarm and sump pump.
- Install a water alarm to inform the homeowner of build up of water in the crawlspace if shown on the plans.
- Install an electrical junction box in the attic space near the passive radon exhaust stack.

Clean up Contractor

Ensure all drains remain clear and water removed from sump pits if necessary by temporary pumps.
Ensure that the integrity of the vapor retarder is maintained or repaired until final completion and occupancy by the homeowner.
The contractor shall remove all nails used for hanging cords, hoses and temporary heating enclosures in the crawlspace.
Clean up any excess debris in the crawlspace and place in trash dumpster at the end of the work day.

- Crawlspace to be left clean of all waste and debris when final occupancy occurs,
- Slab floor is to be broom clean.
- For insect protection provide 3 foot margin of mulch and then climate specific plants around foundation wall

Inspection Checklists

Vented Crawlspaces

NOTE: No one Job Ready checklist is required for Vented Crawlspaces because crawlspaces are constructed by multiple trades. A builder's documented QMS will already have a Job Ready inspection for each of the individual trades that need to include the specific Unvented Crawlspace responsibilities. In addition, a Job Complete checklist is needed for each of these trades' responsibilities. A generic Job Ready Checklist form is included here as an example.

In this Scope of Work the Job Complete inspection form is subdivided by trade to include only the items that each trade would typically be expected to perform specific to

the construction of an unvented crawlspace. All other residential construction items have been excluded from the inspection forms in this scope, but each of the trades' standard Scope of Work should address all aspects of the project pertaining to that trade.

(Insert Builder/Trade Company Name & Logo)

All Contractors

Vented Crawlspace Job Ready Checklist

All items must be inspected and signed off by builder and trade before trade begins work [BCQC1]

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader	**Trade Super**	**Builder**	**Explain Needed Corrections List Date Corrected**
		OK	**OK**	**OK/NA**	
Describe Current Hotspot: Completely filling out checklist forms by site crew		❑	❑	❑	
1.	Job sign and address is posted and visible	❑	❑	❑	
2.	Site access acceptable	❑	❑	❑	
3.	All safety equipment on site and ready to use	❑	❑	❑	
4.	Add trade specific customized items	❑	❑	❑	
		❑	❑	❑	
		❑	❑	❑	
Additional Correction Items:					
			❑	❑	
			❑	❑	
			❑	❑	

Sign here to acknowledge that all above items have been completed	**Trade Signature:**	**Date:**
	Builder Signature:	**Date:**

(Insert Builder/Trade Company Name & Logo)

All Contractors

Vented Crawlspace Job Complete Checklist

Upon completion of work, the trade and builder must verify proper installation and sign off on all items as acceptable. Correction items needing correction must be re-inspected and confirmed-[BCQC-1]

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader OK	Trade Super OK	Builder OK/NA	Explain Needed Corrections List Date Corrected
Excavation Contractor: Name/Date_____					
Describe Current Excavation Hotspot:		❑	❑	❑	
1.	Foundation drains are complete per plans and free-flowing [BCQC-23]	❑	❑	❑	
2.	Crawlspace interior is backfilled and graded with a final grade higher than the final exterior grade per plans with positive exterior drainage on all 4 sides of building [BCQC-23]	❑	❑	❑	
3.	Interior of crawlspace is graded per plan with positive drainage toward any installed drains or to sump pump [BCQC-23]	❑	❑	❑	
4.	Final grade at crawlspace access location shows 4" step down	❑	❑	❑	
Concrete Footing contractor: Name/Date_____					
Describe Current Footing Hotspot:		❑	❑	❑	
1.	All crawlspace drains or sump pump drains are piped through the footing or walls as shown on plans	❑	❑	❑	
Masonry Contractor: Name/Date_____					
Describe Current Masonry Wall Hotspot:		❑	❑	❑	
1.	Flood vents are installed per code where required	❑	❑	❑	
2.	All walls complete per plans including all anchor bolts or tie-down straps properly located	❑	❑	❑	
3.	Wall height is sufficient for required minimum clearance of 24" from finished crawl surface to bottom of framing	❑	❑	❑	
4.	Mechanical openings (wall vents) constructed per plans	❑	❑	❑	
Concrete Wall Contractor: Name/Date_____					

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader OK	**Trade Super** OK	**Builder** OK/NA	**Explain Needed Corrections List Date Corrected**
Describe Current Concrete Wall Hotspot:		❑	❑	❑	
1.	All walls are complete per plans including all anchor bolts or tie-down straps properly located	❑	❑	❑	
2.	Wall height is sufficient for required minimum clearance of 24" from finished crawl surface to bottom of framing	❑	❑	❑	
3.	All forms, bracing, and concrete materials have been removed or recycled	❑	❑	❑	
4.	Walls have operable vents per plans	❑	❑	❑	
5.	Mechanical openings constructed per plans	❑	❑	❑	
Concrete Slab Contractor: Name/Date_____					
Describe Current Concrete Slab Hotspot:		❑	❑	❑	
1.	Capillary break is installed between slab and all walls and piers (BCQC-2)	❑	❑	❑	
2.	Concrete is finished with positive drainage to all sumps and/or drains per plans	❑	❑	❑	
3.	Expansion joint is installed between slab and all walls and piers	❑	❑	❑	
Waterproofing or Damp-proofing Contractor: Name/Date_____					
Describe Current Damp-proofing Hotspot:		❑	❑	❑	
1.	All wall penetrations are watertight [BCQC-23]	❑	❑	❑	
2.	Membrane waterproofing or spray damp-proofing is installed per plans on exterior crawlspace walls [BCQC-23]	❑	❑	❑	
Radon System Contractor: Name/Date_____					
Describe Current Radon System Hotspot:		❑	❑	❑	
1.	Radon collection piping installed per plans	❑	❑	❑	
2.	Riser vent is installed through roof surface	❑	❑	❑	
3.	In-line fan installed and tested (if active system)	❑	❑	❑	
Plumbing Contractor: Name/Date_____					
Describe Current Plumbing Hotspot:		❑	❑	❑	
1.	All drainage to exterior of crawl, (i.e. sump, condensate, water heater temp/pressure relief	❑	❑	❑	

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader OK	Trade Super OK	Builder OK/NA	Explain Needed Corrections List Date Corrected
	valve, etc.) and discharge pipes covered with insect screen				
2.	Floor drain(s) is complete and free flowing	❑	❑	❑	
Termite Protection Contractor: Name/Date_____					
Describe Current Termite Protection Hotspot:		❑	❑	❑	
1.	Soil treated inside and outside crawlspace or Bait traps are installed	❑	❑	❑	
2.	Termite barriers are in place under the lowest level of framing members	❑	❑	❑	
Insulation Contractor: Name/Date_____					
Describe Current Insulation Hotspot:		❑	❑	❑	
1.	Continuous vapor retarder is installed, lapped at least 12", taped, and sealed over 100% of crawl surface and at all pipes and penetrations [BCQC-23]	❑	❑	❑	
2.	Vapor retarder laps a minimum of 6" on all interior piers and posts [BCQC-23]	❑	❑	❑	
3.	Vapor retarder is mechanically attached to wall per plans [BCQC-23]	❑	❑	❑	
4.	All insulation on band joists, and floor is complete per plans [BCQC-16]	❑	❑	❑	
5.	All floor insulation is fastened per manufacturer's instructions [BCQC-16]	❑	❑	❑	
6.	Rigid insulation enclosing above crawlspace floor taped and sealed [BCQC-23]	❑	❑	❑	
7.	Exposed interior insulation has a code approved fire rated covering or surface	❑	❑	❑	
8.	3" inspection gap left at tops of all exterior walls	❑	❑	❑	
HVAC Contractor: Name/Date_____					
Describe Current HVAC Hotspot:		❑	❑	❑	
1.	All A/C condensate drains terminate outside crawlspace [BCQC-23]	❑	❑	❑	
2.	Mechanical ventilation is installed per plans	❑	❑	❑	
Framing Contractor: Name/Date_____					

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

		Crew Leader OK	**Trade Super** OK	**Builder** OK/NA	**Explain Needed Corrections List Date Corrected**
Describe Current Framing Hotspot:		❑	❑	❑	
1.	Overhangs and roof overhangs direct roof runoff away from crawlspace [BCQC-23]	❑	❑	❑	
2.	Crawlspace access door is minimum 24”x30’ and installed with latch, and at least 4” higher than exterior grade	❑	❑	❑	
3.	Install sill sealer under all sill plates[BCQC-16]	❑	❑	❑	
4.	Gasketing above and below band joist is installed for full perimeter of framing [BCQC-16]	❑	❑	❑	
5.	Seal all holes and penetrations in floor system [BCQC-16]	❑	❑	❑	
Electrical Contractor: Name/Date_____					
Describe Current Electrical Hotspot:		❑	❑	❑	
1.	Non-switched GFCIs located in attic near radon riser and in crawlspace near all equipment	❑	❑	❑	
2.	Wiring to humidity monitor and water monitor complete and operable	❑	❑	❑	
3.	Crawlspace lighting and service receptacles installed per plans with switch near access point	❑	❑	❑	
4.	Electrical junction box in the attic space installed near the passive radon exhaust stack	❑	❑	❑	
Clean up Contractor: Name/Date_____					
Describe Current Clean-up Hotspot:		❑	❑	❑	
1.	All exterior drains and sump drains clear and free flowing before homeowner move-in	❑	❑	❑	
2.	Polyethylene in crawlspace is continuous and any holes or tears are repaired [BCQC-23]				
3.	Crawlspace broom clean (if slab floor) and free of all trash, temporary nails in framing, temporary polyethylene, and debris before homeowner move-in	❑	❑	❑	
4.	18” clear margin of mulch or plants outside of crawlspace wall [BCQC-23]	❑	❑	❑	
Additional Correction Items:					
			❑	❑	
			❑	❑	
			❑	❑	

Builder:	**Lot:**	**Subdivision:**
Builder Supervisor Name:		

Instructions: Check box if ok, circle box if correction is needed. Note specific correction action required. When corrected, then check box.

	Crew Leader	**Trade Super**	**Builder**	**Explain Needed Corrections List Date Corrected**
	OK	**OK**	**OK/NA**	
Sign here to acknowledge that all above items have been completed	**Builder Signature:**			**Date:**

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Appendix D: Hotspot Implementation Guide & Tools

Introduction

The goal of Building America is to develop energy efficient solutions for new and existing homes that meet increasing energy performance targets. In order to consistently deliver production scale new high performance homes, quality management is needed. The goal of implementing a quality management process is the prevention of problems, issues, and defects. While prevention is the ultimate goal, part of a quality management process includes managing issues that do occur. This report outlines how to address recurring problems within the context of a builder constructing new high performance homes.

The hotspot process is a quality management tool that was developed by the NAHB Research Center under the NHQ Certified Trade Contractor Program to support quality efforts to prioritize and greatly reduce recurring problems. The intent of the Hotspot Implementation Guide and Tools is to provide a resource for builders and their trade contractors that allow them to take on a self-contained quality management process that is not dependant on having a formal quality management system in place.

Addressing Recurring Problems - Hotspots

A hotspot is a recurring problem or potential problem that a building company chooses to target for elimination or prevention because the leaders in the company have carefully analyzed the company's problems and concluded that this particular problems ranks as the most important one to address at this time. Eliminating a hotspot will require the use of time and company resources. Specific hotspots are selected because they are:

- A prioritized, important issue.
- A builder's problem, not that of another company
- An issue that is limiting a builder's effectiveness or efficiency.

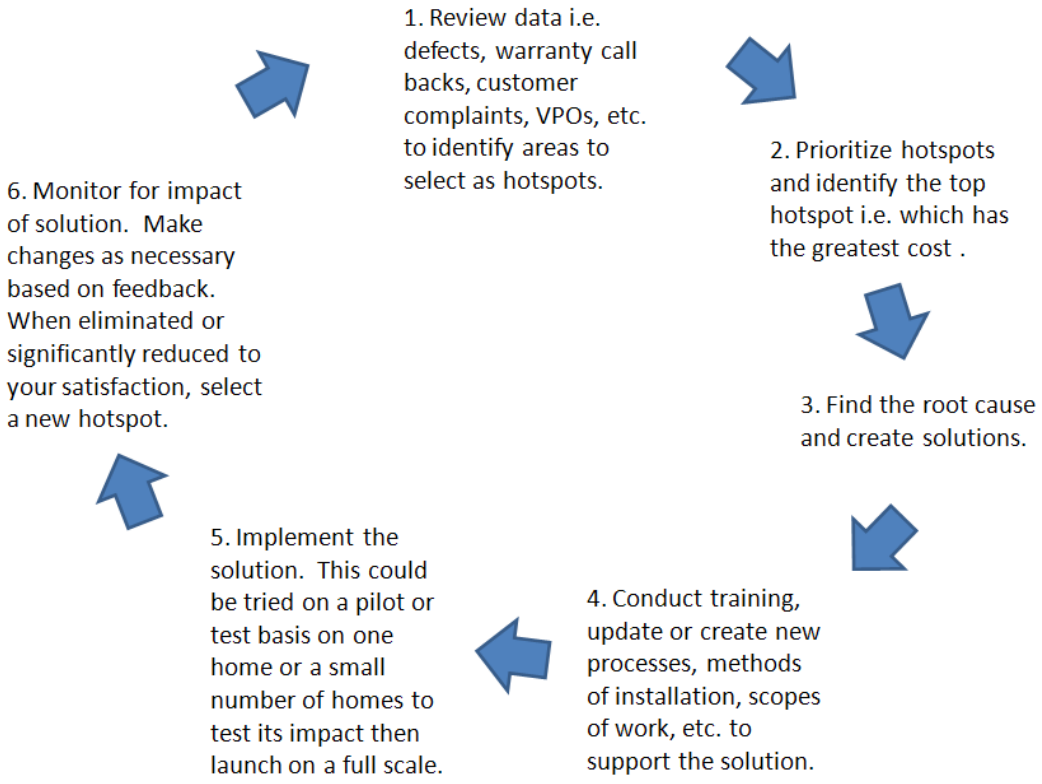
By eliminating hotspots, costs can be reduced, profits increased, and customer satisfaction improved, and ultimately the company is made stronger and more sustainable. This is of particular importance in high performance homes because the home must work as a system to achieve the desired energy performance without issues such as durability, moisture, indoor air quality, comfort, etc.

The chart below highlights some common hotspot categories, though it is not intended to be a comprehensive list of all possible hotspot types.

Jobsite Installation	Office Operations	Personnel Or Company Culture
Material failure	Inventory control	Low morale
Product failure	Documentation	Culture of finger-pointing
Inefficient installation	Accounts payable/receivable	Lack of accountability
Safety issues	Maintenance of records	Lack of pride
Improper installation	Poor Communication (i.e. between office and the field)	Poor communication
Poor communication	Coordination/accountability of field personnel	

Hotspot Process

A hotspot is often found by reviewing data such as warranty data or customer complaints. Following this, the identified hotspots then need to be prioritized. Then the cause of the issue needs to be determined to create a solution. Next, the solution needs to be communicated, implemented, and then monitored for impact. This process is shown in detail in the figure below and in the list following.



Six Steps to Eliminating Recurring Issues (Hotspots)

1. Review data from inspections, callbacks, code inspections, and customer feedback to choose hotspots.
   (Responsibility: The person who reviews inspection data)

2. Prioritize hotspots and identify the top hotspot
   (Responsibility: Quality Manager)

3. Perform a root cause analysis to determine why the hotspots occur and create a solution for the issue.
   (Responsibility: Quality Manager)

4. Add the hotspot item to the inspection process and inspection form as a specific, stand-alone item.
   (Responsibility: Office worker/Field supervisor)

Develop a training format (i.e. training sheet, video etc.) to address the root cause of the hotspot.
(Responsibility: Quality Manager)

5. Implement the hotspot training to all workers and inform them that there will be inspecting for and tracking of the success of the hotspot item on every single job.
(Responsibility: Field supervisor who oversees field operations)

6. Inspect every job, every time, for the hotspot. Monitor for the impact of the solution.
(Responsibility: Inspector)

   Review and tabulate the results periodically to evaluate hotspot success and provide feedback to the entire company.
(Responsibility: Quality Manager)

If the process is successful after one month of addressing the issue, the quality manager should recognize those who have contributed to its improvement. At this point, the hotspot is resolved and it can be removed from the inspection criteria or demoted to non-hotspot status, and repeat the process. However, if the hotspot improvement is not as successful, the quality manager should repeat the process to determine why the condition was not corrected. The training may need improvement or a different root cause may need investigation beyond the one originally addressed.

A Hotspot Is Not!

There are occasionally some issues identified that are not actually a hotspot. These include:

- A problem that the company no longer has
- An external problem for which the company has no direct participation in causing (the exception to this is ***only after*** a company has exhausted their internal hotspots)
- A relatively unimportant issue
- An issue that is linked to just one individual or crew, unless its impact is so great that it affects the entire company and rises to the level of most important problem to be addressed at that time.

Actual Examples of Typical Hotspot Problems

When occurring frequently, the following are examples of what a hotspot can be including:

- Gaps and voids regularly found in the installation of batt insulation
- Improperly sealed penetrations
- Inconsistent or wrong nailing patterns
- Inspections not being done, or not being documented
- Workers on the jobsite failing to follow safety procedures such as not wearing hardhats
- Drywall seams closer than 8 inches from openings
- A trade beginning work without the required conditions
- Crews running out of or not having all of the needed materials at the jobsite
- Excessive waste or theft of materials

Why Do Hotspots Work?

Hotspots work because when implemented properly, they prioritize challenges within a company, target training to those problems one at a time, and then track improvements resulting from the hotspot

training. Improved knowledge and awareness of problems along with careful monitoring and tracking lead to increased accountability for all workers. Issues targeted by an effective hotspot process typically are virtually eliminated. Once individuals actively participate in eliminating some of what have often been on-going, frustrating problems, they are empowered, and begin to develop a greater sense of control over their workplace success. This can be an important step in the process for a company to begin to create or enhance a culture of quality across its entire operations.

Create Accountability with Workers

The principle of the hotspot process is to focus on what's most important, and to limit one's effort to a single issue at a time, and then to actually monitor the success in eliminating the problem. Focusing the efforts on a single issue creates accountability because after training on that issue, no installer can claim that he or she did not know how to do it correctly, or that they forgot, that they did not think it was important, or any other similar excuse. This creates bottom-line accountability with no room for excuses. This creates successful results.

Identifying the Hotspot

Identifying hotspots can be simple. A builder documenting inspections of construction, supply, or installation, will have data to review in order to determine what problems are occurring, at what frequency, and at what cost to the company. If this kind of data in place, then it can be reviewed for hotspots. Start with information already available and review the records of production callbacks, warranty callbacks, return trips, etc to identify recurring problems. If a builder has a database of inspection data, they may be able to simply print out a report that will indicate the frequency and type of callbacks.

If this data is not available, then a builder may have or choose to create a different approach. Some methods include something as easy as an Excel spreadsheet or even a simple manually recorded tick list of callbacks to indicate which of callbacks are most common. In addition, initial hotspots can be selected based on what is perceived to be the greatest need for improvement. This should be the only time that hotspots are identified based on perceptions rather than data. Perceptions are often misleading, whereas inspection data rarely deceives.

This also reflects just one reason why conducting inspections and keeping inspection forms is so important. Conducting inspections is a key way to avoid errors and to find out where the problems lie. It also allows a builder to monitor when such problems have been eliminated. Other sources of data may be available such as variance purchase orders (VPOs), customer complaints, warranty issues and customer survey results.

Consider These Questions To Identify Hotspots:

- What is the greatest area in need of improvement?
- Is there a particular installation issue, fabrication issue, supply issue or paperwork/office issue that is hurting the builder's operation?
- What is the leading cause for return trips to the jobsite? What are the most expensive reasons for callbacks?
- What is the leading cause for warranty callbacks? What is the most expensive warranty callback?
- What is the worst problem or bottleneck in the office?
- What are the greatest product inventory or fabrication issues?

- What are the areas of improvement that customers would most like to see improvement?

Prioritize Hotspots

The next step following identifying hotspots is to prioritize which is the most important. The importance can be based on cost, the largest scheduling issue, or the item causing the most harm to a builder's business operation. Experience working with builders and trade contractors has demonstrated that individuals and companies often focus on too many problems or ones that simply do not rise to the top in terms of importance. This is why the hotspot process is most successful when hotspots are chosen not by what the owner or a manager thinks is a serious problem for the company, but rather what the analysis of inspection and other data indicate the company's most important challenge to be. Additional information on what data to collect, how to analyze it and how to effectively select a hotspot is explained in more detail in the section on tips for selecting a hotspot.

There are two approaches to construction management issues that are guaranteed to fail; either to ignore all of the problems or to try to tackle them all at once. The most common point of failure from well-intentioned business owners is that they try to take on too many problems at once, and they end up solving none of the problems because their efforts are too diluted. Either the owner becomes overwhelmed, or, in many cases, the workers are not given any area of priority or focus in order to address the issues, resulting in none of the problems being eliminated.

Address One Topic at a Time

The impact of addressing a single problem is critical. By prioritizing a particular challenge within a company and only targeting that particular issue at that time, individuals at the company are empowered to focus their attention on that particular issue. Instead of being overwhelmed by trying to correct 10 issues at once, focusing on one issue allows a worker/installer to take on a manageable amount of learning and implement a bite-sized amount of change. Likewise, an onsite inspector can implement, inspect and track a manageable amount of change at a given time. This is important because the common management mistake at many companies is that they attempt to correct too many items at once, rather than prioritize and focus on one item. The end result of trying to correct too many things at once is that workers become overwhelmed and are not able to consistently and adequately address any of the items. Calling too many problems very important all at the same time has the effect of making none of them important.

Root Cause Analysis of the Hotspot Problem & Creating a Solution

Once a builder has determined what the problems are, and prioritized them to decide which to address first, the next step is to consider what may be the actual root causes of the problems. Only after having done this analysis can a builder evaluate what the best possible solutions might be to effectively reduce or eliminate the problems.

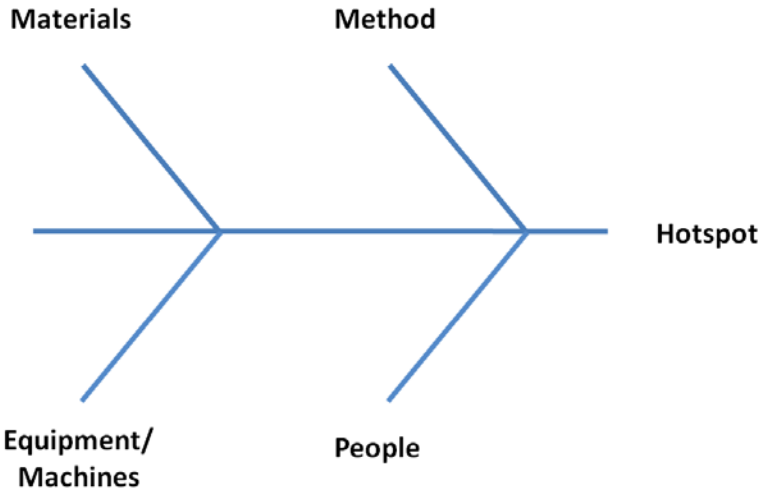
Root Cause Analysis

There are a range of tools and techniques that can be used to find a root cause and create a solution. One is the 80/20 rule. This means that usually 20% of the issues cause 80% of the problem. This allows a builder to focus and determine solutions most effectively.

For example, assume that the hotspot is that a builder's warranty costs are too high. Remember in this example while the aim is to reduce costs, there will also be reductions of warranty complaints resulting in improving customer satisfaction and perhaps also increasing referral rates. The first step is for the

builder to break down the warranty costs down into the component parts (the accounting department can help here, based on the builder's specific coding systems for costs). Next, rank the warranty cost issues from most expensive to least. The results will show that a few (20%) of the issues represent the majority of the costs (80%). Select the highest cost issues and consider which of these a builder can potentially impact easily and quickly.

This process can take time defining the problem. In addition, correctly identifying the problem is key to finding the true root cause. One tool that can help at this point is the fishbone chart show below.



Each 'bone' of the chart highlights an area to consider. Under each heading or bone, list what is already known about the problem. Note, for example, under people: list everyone involved in the aspect of the warranty problem. Then under Equipment/ Machines list what equipment is used. Do the same under Materials and then outline the Method of installation by listing the key steps in that process. This allows a thought process to review each of these issues and eliminate what is not contributing to the problem and therefore isolating what is causing the problem.

Another tool is process mapping or flowcharting. This can be very simple. Create a simple box for each step in a process with a note of what occurs, who is involved, and how long the step takes with an arrow connecting each box or step to the next box. This can help identify bottle-necks; find ways to eliminate steps and make improvements to the process. The result is an 'existing' process map and possibly a 'new improved' process map.

Creating a Solution

At this point it is important to talk with representatives from all the departments that have an impact on this hotspot area (for example: customer relations, construction and design). It is also important to talk with the trades that work prior to, on this issue and after this issue in the construction process. From these groups who know exactly what happens on a daily basis in this area, find out what the problems are, what the frustrations are, and even suggestions for potential solutions. By working with these groups a builder can get a clear overall picture. Also consider talking with the customer (homeowners) view point also through customer complaints, completed satisfaction surveys and interviews.

When there is a clear perspective of the issues a builder may want to form a team with a representative from each group so that the problem can be clarified and potential solutions evaluated. In addition, there are outside resources for a builder and trades that can help including NAHB Builder 20 Club colleagues or members of the local Home Builders Association. These industry groups may have already experienced the same problem and be able to provide actionable solutions. The goal is to combine the suggestions into the actionable solutions to the issue in order to address the hotspot. Be sure that everyone involved in the process has been engaged in the root cause identification and the creation of the solution.

Add Hotspot to Documentation & Develop Hotspot Training

Hotspot Documentation

When a solution or set of solutions has been identified, ensure that they are documented. For example, test-drive a new improved process map so everyone can see and understand what the changes are and who is responsible for each step in the revised process. Develop revised scopes of work, revised specifications and drawings or details if needed. In addition, training on the new process and the new documents is essential as well as a schedule for launching the new process.

Hotspot Training Development

Based on the documentation for the hotspot solution, the next step is to develop training. The goal of the initial hotspot training session is to explain the hotspot so that all parties understand what the problem is, why it is important to avoid the problem, and the costs and problems that come out of the hotspot issue. For field crews, this can be done in the field much like a toolbox safety talk, which are done on jobsites with workers as an efficient training approach that causes minimal interruption to the work. Many companies find it effective to deliver their field hotspots during their toolbox safety talks. Hotspot training for field crews can also be delivered in the office or yard as part of another meeting or when crews have a separate reason to be at the office/yard. Hotspots that target office personnel or fabrication or supply yard workers can be delivered in the yard or office in conjunction with a safety talk or other meeting as is convenient and efficient for each company.

Hotspot Training Sheets

One important piece of the hotspot training is the development of a training sheet describing the hotspot and the solution. An effective hotspot training sheet should be relevant, focused on a specific issue, and should use graphics rather than language to communicate the message. A hotspot training sheet should target one specific problem, outline the primary cause of that problem, and depict the solution.

For example, a roofer's hotspot was torn felt. After some discussion, it was determined that there were three likely causes of the torn felt: 1) the roofers were stepping in the valleys, 2) the roofers were not lapping the felt properly, and 3) the roofers were not pressing the felt into the valleys. Rather than train the installers on all three possible causes of this issue, the roofer determined that the most important cause was improper lapping of the felt. The roofer reasoned that if the felt were lapped properly, that it would not matter much if workers stepped in the valleys or if the workers did not press the felt into the valleys, because the properly lapped felt would not likely tear. This roofer then just trained his installers on the one most important cause of his torn felt issue. If the issue were still not resolved after the roofer addressed what he thought to be the leading cause, then he would train his installers on the next most important cause, until the problem were essentially eliminated.

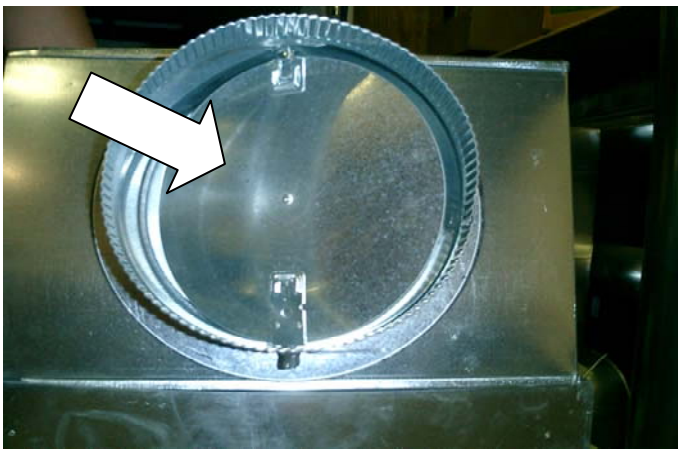
Using this information from the hotspot process, the next step is developing the training sheet to graphically depict the issue, the primary cause, and the proposed solution. An example hotspot sheet is shown below for another hotspot, installing mechanical dampers on supply air duct lines. The example below includes steps/suggestions for creating the hotspot training sheet. A complementary effort to developing the hotspot training sheet is also a sign-in sheet for the training to document the date and attendees of the training.

Wittman Mechanical Contractors, Inc.
The Right Solution Every Time

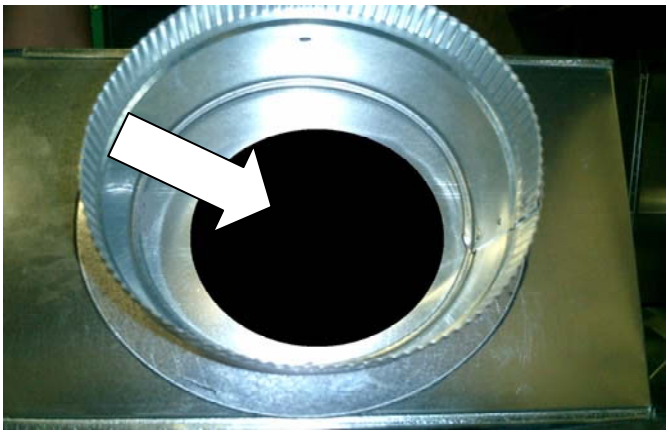
Quality Assurance Program
Monthly Hot Spot 8/09

Mechanical dampers are to be installed on all supply-air duct lines off the plenum.

Right



Wrong



Courtesy of Wittman Mechanical Contractors, Inc.

1) Use two identical pictures except for the issue being highlighted

2) Use symbols, NOT words to identify the right and wrong method

3) If you use any text, include it in both English and a second language as appropriate

4) Use arrows to focus attention directly on the issue being addressed

5) Only address one issue per training sheet

6) Choose training topics by analyzing the frequency and importance of problems from documented inspections or other data

7) Use clear photographs drawings that are easy to understand without reading any text

Training Instructions:

1. All crew members and all crew leaders must attend session.
2. Lead man explains the problem and the proposed solution.
3. Everyone examines both pictures and all notes.
4. Lead man answers any questions.
5. All crew members and crew leaders sign below.
6. Lead man signs and dates bottom of page.

8) Include training tips and a sign-in sheet as part of your hotspot training sheet

TIME MEETING STARTED: _____a.m./p.m._____

ATTENDEES:

_____(PRINT NAME)_____ _____(SIGNATURE)_____

_____ _____

_____ _____

_____ _____

_____ _____

Implement Hotspot Training & Solution

Following the development of the hotspot documentation and the hotspot training sheets, the next step is implementing the training itself. In order to maximize effectiveness of the hotspot training it is helpful to limit the training topic and the amount of time for the training-typically, a hotspot training session should only last 5-10 minutes. During the training, make sure to cover the primary elements of a hotspot training session: what the problem is, why it is important, and the solution for the issue.

It is very important when delivering a hotspot training that the solution being trained actually addresses the root cause of the hotspot so that workers are empowered by the training to succeed in eliminating the hotspot. There are, of course, some hotspots whose root cause is simply to focus more carefully on a particular aspect of the work in order to achieve the desired outcome. However, always be sure to provide solutions to root causes of hotspots where possible.

Components of a Hotspot Training Session

There are six components to a hotspot training session including the following:

1. Summarize the results of the last hotspot that was trained. Use data as much as possible, such as the number of return trips or reworks that were reduced compared to the previous month. Whenever possible, define how much savings can be attributed to the hotspot improvement. If customer satisfaction has been affected, discuss that as well.

2. If a builder has achieved the desired results from implementing the hotspot, recognize the contributions of those who have helped the company improve in this area. Celebrate the successes with the participants. Sincere recognition and the expression of appreciation for a job well done can be a very effective means of reinforcing good results and new good habits

3. Explain exactly what the new problem (hotspot) is.

4. Discuss the impacts of this high-priority recurring issue. Discuss this in terms of number of return visits, estimated cost, or impact on customer satisfaction.

5. Discuss the cause of the recurring hotspot issue.

6. Explain exactly what workers need to do differently to solve the problem.

Hotspot Training Tips:

Hotspot training should be given to all crews or individuals who perform the task being trained on.

Hotspot training should *NOT* be targeted just to the problem crew(s) or individual(s), rather its implementation should be universal.

Done this way, hotspot training enables a company to eliminate specific challenges from all of their projects in a proactive manner, rather than by addressing them as they arise on a crew by crew or worker by worker basis.

This approach also builds on the culture of quality within the company, since the problem being addressed is not being blamed on specific workers, but is targeted to the entire operation.

Using this approach, the company has identified a quality challenge to eliminate, and it is everyone's responsibility to contribute to the elimination of that particular problem.

Implementing Solution

Following the training, the hotspot itself needs to be implemented. To this end, there are ways to continue to reinforce the initial hotspot training session and to encourage success. Three methods include:

1. The crew leader begins each and every day by reviewing the hotspot with the crew. This is not the full hotspot training, just a reminder about what to do or not to do. This keeps the current hotspot issue at the forefront of the minds of the crew.

2. Post a display showing the hotspot issue and its solution for example a photo of the correct and incorrect way of installation. This display of the hotspot should be in a place where it will be seen frequently by those to whom it is directed. A loading issue, for example, would be clearly posted on the loading area so that every time workers are loading they would likely see the hotspot and be reminded of proper procedures.

3. Include a specific hotspot item on the inspection form (delivery, fabrication, installation, etc) and require that it be verified on EVERY SINGLE job. Even better, include the right way/wrong way pictures on the inspection form so that there is a visual reminder for individual filling out the inspection form.

In many situations the broad-scale implementation of the solution will directly follow the hotspot training. However, there are also methods of implementing the solution incrementally to ensure that it works. One successful method is to conduct a trial run or pilot on a house or series of houses to test the new solution or process to ensure it works. Following this the solution would then be implemented on a broad scale.

Tracking & Monitoring Hotspot

The final step of the hotspot process is to track and monitor implemented hotspots. In order to be effective, hotspot compliance must be tracked on a regular basis by management and the results must be reported back the crews so the crews know that management knows exactly how well or not so well that each crew is performing related to that particular hotspot. Tracking data can be tabulated on a weekly or monthly basis with results posted in a public place for everyone to see. Table 4 (shown below) is an example of a simple spreadsheet hotspot/inspection log that a company can use to track and evaluate inspection results including the hotspot. Some companies may have more sophisticated databases from which they can print useful reports; other companies may use a simple hand-written list. What is important is that a company monitors and tracks its performance using whatever technology that company deems appropriate.

HOTSPOT/INSPECTION LOG

Builder/Lot	Numbered Inspection Items from the Job Complete Ins								
	Hotspot Item	**Item 1**	**Item 2**	**Item 3**	**Item 4**	**Item 5**	**Item 6**	**Item 7**	**Item 8**
Smith Building			2						
Elders 23			1						1
Elders 24	1								
Elders 25			1			1			
Elders 26									
The Meadows 12									
The Meadows 13									
The Meadows 14	1								
The Meadows 15									
The Meadows 16			1						
The Meadows 17									
						1			
R&R Custom Homes									
1002 Peaceful Way		1		1					
1004 Peaceful Way			1						
1006 Peaceful Way	1							1	
1008 Peaceful Way			1						
Total	**3**	**1**	**5**	**1**	**0**	**1**	**0**	**1**	**1**

Table 4 – Spreadsheet to Track Construction Callbacks by Issue and Location

What to Do When the Hotspot Continues To Be a Problem?

If after tracking hotspot results for a month the problem remains, either the cause addressed was not the right one or not the only one, or the training process was ineffective. At this point, it is time to evaluate and determine whether it is necessary to address a different cause or retrain on the same cause more effectively, and proceed through the hotspot process accordingly.

Hotspot Activities Schedule								
Date	**Hotspot Description**	**Reported By**	**Cause**	**Training / Other Planned Action**	**Follow-up**	**Date**	**Hotspot Results**	**Date Closed**
1/5/2010	Ducts not sealed properly at air handler	Inspection Sheet analysis	Not pre-attaching the ductwork prior to setting the air handler	Train installers to attach and seal the ductwork to the boiler prior to setting the air handler	None	2/5/2010	Only one duct sealing problems on inspection forms	2/5/2010
2/6/2010	Missed sealing of some HVAC building envelope penetrations	Inspection Sheet analysis	Penetrations not sealed as made, some are missed when doing all sealings at the end of the job	Train installers to seal each penetration immediately after making the penetration, not at the end of the job.	None	3/5/2010	Better than 90% of the jobs have all penetrations sealed properly	3/5/2010
3/4/2010	Poorly sealed ducts at any connection point	Feedback from builder	Not using sufficient mastic to seal the ducts	Train installers to completely cover seams with mastic	None	4/5/2010	Better than 90% of the jobs have all ducts sealed properly	4/5/2010

Table 5 – Schedule of Hotspot Activities

If the hotspot is ineffective, perhaps the training message was unclear or ineffectively delivered such that the workers being trained did not understand. Or, consider that there may have been breakdowns in the inspection process such that accountability was not created for those individuals responsible for changing their practices and eliminating the hotspot. Always continue to work through the hotspot process until the hotspot occurrence is reduced to an acceptable level. For most builders, reducing a known recurring problem by 50% or more may seem like success, but for the hotspot process to work best, it is recommended that the threshold be significantly higher, more on the order of 80%-90%. Each builder must evaluate what threshold is appropriate for each type of hotspot, but management should be careful not to dwell on a single hotspot for several months just because the problem has not been completely eliminated in 100% of the time. The Hotspot Activities Schedule in Table 5 (shown above) allows a company to monitor all of its activities associated with the hotspot and to retain a record of the hotspots addressed and the company's success in addressing them.

9 Recommendations to Effectively Address Hotspots

Finally, based on the process outlined in this report and the experience of the NAHB Research Center through the National Housing Quality program, there are some recommendations to increase success in effectively addressing hotspots. These nine recommendations include:

1. **Picking hotspots that are within the direct control of the company** - Picking hotspots that are within the direct sphere of influence of the company itself, (at least initially while establishing a culture of quality and a successful hotspot program), is important. A company should initially focus inwardly and become the best possible company it can before attempting to create change in other partner companies. This is because a company will have much greater credibility and success in addressing external problems in other companies only after it has established itself as a quality-oriented company.
2. **Prioritizing the hotspot selection process so important hotspots are addressed** - Addressing important issues will result in momentum for quality improvement and the quality efforts because successes will be, by design, important. This will also help a builder address one topic at a time and focus to address on hotspot before trying to improve another.
3. **Asking workers to correct a problem by addressing the underlying root cause to achieve the desired results** - It is the job of management to provide solutions for workers that addresses the underlying root cause of the issue. As a result, it is the role of management to provide the information, tools, and/or resources for workers to intentionally make an adjustment to address the root cause of the hotspot.
4. **Developing effective training sheets/tools**
    a. **Use pictures** - Pictures allow passive learning and re-enforcement of the intended lesson to occur. The goal is that using pictures an individual can understand the message without having to extensively study sheet. In addition, a passerby can passively understand the hotspot from casually glancing at a paragraph explaining a construction concept. Hotspot training sheets that do not utilize pictures creates a language barrier for anyone who does not read English (or the language the training sheet is written in).
    b. **Using photographs of good quality** - This is obvious: a good quality photograph or detail increases the effectiveness of the hotspot training.
    c. **Show both the right and the wrong way with pictures** - Showing both right and wrong methods and clearly identifying right versus wrong makes it easier to understand the message.

   d. **Use two identical pictures except for the specific item that is the hotspot** – As with showing the right and wrong way with pictures, this makes the message easier to grasp because it is not necessary to study the pictures to look for the issue at hand.
   e. **Show only one mistake in pictures** - This upholds the basic premise of a hotspot to clearly focus on one problem at a time.
   f. **Address the root cause of what needs to be done** - Of course, the intent of a hotspot training sheet is to address the actual or root cause, so it will be effective in eliminating the issue.
5. **Train all of the workers who touch the hotspot** - Train all workers who may potentially make the mistake that is the hotspot, because the hotspot process is intended to focus on those individuals who have made the mistake, as well as to teach anyone who might make the mistake in the future the correct way to do the concept being trained in the hotspot. This also brings accountability to all of the workers since everyone receives the training and is expected to do that particular hotspot item correctly in the future.
6. **Inspect every job for addressing the hotspot correctly** - The success of addressing the hotspot is increased when workers are accountable and know that every job is inspected to ensure that the hotspot is correctly addressed. In addition, inspecting for proper hotspot execution will significantly increase the effectiveness in eliminating the problem
7. **Monitoring and tracking/evaluating the results of the hotspot and sharing those results with the entire company** - Tracking and monitoring provide accountability because in the eyes of workers, it matters. In addition, tracking and monitoring allows the builder to determine if the issue has been successfully eliminated.
8. **Implementing the suggested practices so that adjustments can be made to customize the approach to best fit a company's existing procedures and culture** – It is helpful to recognize that they sometimes the hotspot process must be customized to the culture and existing practices of a company in order to be implemented effectively and efficiently.
9. **Effectively communicating the importance of continuous improvement and the hotspot** - If the hotspot process and quality improvement are not obviously important to management as demonstrated by management's commitment and passion for quality improvement, it will not be important to workers. This is where senior management must clearly demonstrate a commitment to the principles of continuous improvement and quality management in general. Often this is best exemplified by recognizing the success in addressing a hotspot.

Summary

To consistently deliver production scale new high performance homes, quality management is needed. Since prevention is the ultimate goal, one focus of quality management is how to handle problems that do occur by addressing their root causes to prevent their recurrence. A hotspot is a recurring problem or potential problem that a building company chooses to target for elimination or prevention. This is of particular importance in high performance homes because the home must work as a system to achieve the desired energy performance without issues such as durability, moisture, indoor air quality, comfort, etc.

A hotspot is often found by reviewing data such as warranty data or customer complaints. Following this, the identified hotspots then need to be prioritized. Then the cause of the issue needs to be determined to create a solution. Next, the solution needs to be communicated, implemented, and then monitored for impact. By eliminating hotspots, costs can be reduced, profits increased, and customer satisfaction improved, and ultimately the company is made stronger and more sustainable.

The hotspot process is a quality management tool that was developed under the NHQ Certified Trade Contractor Program to support quality efforts to prioritize and greatly reduce recurring problems. The intent of the Hotspot Implementation Guide and Tools is to provide a resource for builders and their trade contractors that allow them to take on a very important element of a quality management system and to reap its benefits almost immediately. In addition, the Hotspot Implementation Guide and Tools is a self-contained quality management process and is not dependant on having a formal quality management system in place. Therefore, it can be used by high performance home builders as an incremental step to a formal quality management system.

Next Steps

The next step for hotspots for high performance home builders include working with a builder specifically through the hotspot process as a specific case study. This will serve as an example of the hotspot process and reducing recurring issues.