BUILDING TECHNOLOGIES PROGRAM

Strategy Guideline: Advanced Construction Documentation Recommendations for High Performance Homes

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Building Science Corporation

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Unless otherwise noted, all figures were created by Building Science Corporation.

Definitions

ABS	Air barrier system
BA	Building America Program
BFRL	NIST's Building and Fire Research Laboratory
BIM	Building information modeling
BSC	Building Science Corporation
NZE	Net zero energy
NZERTF	Net Zero Energy Residential Test Facility
NIST	National Institute of Science and Technology
QC	Quality control

Introduction

As whole-house energy efficiency increases, new houses become less like conventional houses that were built in the past. Higher energy performance is achieved by optimizing conventional components as systems. New materials and new systems, which are expected to perform at a higher level, require greater coordination and communication between industry stakeholders. These changes mark a departure from the traditional “labor + materials” approach, where individual materials or components could be substituted for higher performance elements, toward an increased focus on the design and construction of whole building systems, where the process of construction and the interaction of components is more critical to the performance of the final product. To achieve the level of communication and coordination required, the approach to the assembly and use of construction documents needs to be improved. *Strategy Guideline: Advanced Construction Documentation Recommendations for High Performance Homes* provides advice to address this need.

The Guideline identifies differences between the requirements for construction documents for high performance housing and the documents that are typically produced for conventional housing. The reader will be presented with four changes that are recommended to achieve improvements in energy efficiency, durability, and health in Building America (BA) program houses: create coordination drawings, improve specifications, improve detail drawings, and review drawings and prepare a Quality Control Plan. Each recommendation is discussed using lessons learned from the National Institute of Science and Technology (NIST) Net Zero Energy Lab House, a recent Building Science Corporation (BSC) BA project that will test the implementation of energy efficiency technologies intended for future use in production homebuilding.

BSC has prepared this Guideline for designers and builders of high performance new homes similar to work done by BA.[1] This Guideline addresses improvements to architectural documentation (i.e., plans and specifications), which will have an impact on construction administration, construction quality control, and energy efficiency program requirements, but these issues are not directly addressed in this Guideline.

[1] BA is part of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program. The long-term goal of BA is to develop cost-effective, production-ready technologies to be used in new and existing homes in five major climate zones. BA homes are high-quality, energy-efficient homes that are healthy, durable and safe. More information about BA can be found at www.buildingamerica.gov.

1 Risk Identification

1.1 Designing High Performance Homes

High performance housing—the kind of housing that is the focus of the U.S. Department of Energy's BA—is unlike conventional housing in that a higher degree of coordination and communication is needed to ensure that the expected level of whole-house energy performance is achieved. One reason for this need is straightforward: reaching the performance goals often involves new technology and new construction techniques. But more fundamentally, many of the new technologies and new techniques are "whole-building" systems that involve the coordinated effort of multiple trades.

For example, the levels of airtightness needed to reach the BA minimum standards[2] require a complete air barrier system (ABS) that achieves continuity through all of the major assemblies (foundations, above-grade walls, roofs) and all other enclosure components (windows, doors, mechanical penetrations). Depending on the technology chosen, an ABS may involve the foundation contractor, the framing crew, insulation installers, the gypsum board contractor, the heating, ventilation, and air-conditioning (HVAC) installer, electricians, plumbers, roofers, and telephone, security system, and cable installers. The final performance of the ABS depends on the work of each of these trades and is inspected by the architect, the builder's site supervisor, the Home Energy Rating System rater or energy consultant, and/or the building code official. At lower-than-BA levels of airtightness, the designer and builder depend on conventional or traditionally accepted scopes of work, trade experience, and "normal" quality control procedures. When every hole in the enclosure matters for the performance of the ABS, a higher level of communication and coordination is needed—sometimes requiring unconventional documentation. The same is true of other technology such as roof-mounted photovoltaic or solar hot water panels, high R-value hybrid wall systems, combination space heating and hot water systems, advanced lighting systems, and home energy management systems.

Although every house project requires good documentation, the higher level of communication needed to achieve high performance objectives requires that some changes be made that are beyond what may be considered the good conventional set of drawings and specifications. Changing energy codes and homeowner expectations mean that conventional housing will shortly become high performance housing. This Guideline describes improvements to conventional construction documents that are needed to communicate the design intent and proper field execution of new technologies and new techniques in high performance housing. The following sections deal with these recommendations in more detail, using the NIST Net Zero Energy Lab House as an example of housing that will meet future performance standards.

[2] Building Science Corporation (September 2009). "Info-001: Residential Best Practices Criteria." Building Science Corporation, www.buildingscience.com/documents/information-sheets/residential-best-practices-criteria?topic=doctypes/information-sheets. Accessed June 15, 2011.

2 Tradeoffs

2.1 Communicating Design Intent With Conventional Documents

Design intent is communicated through the contract documents, which typically include the agreement (between client and builder or between builder and the trades), the drawings, and the specifications. The set of drawings includes:

- **Architectural drawings.** Floor plans, elevations, and sections to describe the proposed building, with schedules for finishes, doors, windows, and hardware. Information about the construction may be included as detailed wall sections or individual details, both keyed to the building drawings.

- **Structural drawings.** Often included as annotations to the architectural drawings and specifications, but may be included as a separate series of drawings.

- **Mechanical and electrical drawings.** Typically a separate series of drawings showing equipment layout, duct layout and equipment schedules—performance information may be noted on this drawing (e.g., register flows).

- **Site servicing, grading and landscaping drawings.** Could be part of the architectural set, but in a production environment servicing, grading, and landscaping information is typically provided at the subdivision scale with only minor notes on grade and subgrade information on the architectural set. Orientation of the houses is also established on a subdivision scale.

The drawings are read with the specifications, which describe the work by component and the materials to be used. Often this information is integrated into the drawing set as a specifications sheet (see the example in Figure 1).

In other cases, specifications are provided in the more detailed MasterSpec format that was developed by the American Institute of Architects. MasterSpec specifications are divided into major construction groups and provide information for each element of the building (see Figure 2). This document is included in a project manual, which will contain other information about the project including general conditions and instructions to bidders, etc. It is also common to find the specifications included in trade scopes of work that form the basis for a contract with the general contractor.

GENERAL CONSTRUCTION NOTES

CIVIL NOTES:
DEBRIS - REMOVE DEBRIS WITHIN 2'-0" OF BUILDING.

EXTERIOR GRADE - SLOPE GRADE 5% TO DRAIN AWAY FROM BUILDING.

SOIL GAS CONTROL - ALL WALLS, ROOF AND FLOORS IN CONTACT WITH THE GROUND SHALL BE CONSTRUCTED TO RESIST THE LEAKAGE OF SOIL GAS FROM THE GROUND TO THE BUILDING. A PASSIVE SUB-SLAB DEPRESSURIZATION SYSTEM IN ACCORDANCE WITH THE SUPPLEMENTARY GUIDELINES SHALL BE PROVIDED: 1 VENT PIPE, MIN. 4" DIAMETER, PER 1500 SF OF SLAB AREA VENTED THROUGH ROOF.

STRUCTURAL NOTES:
CONCRETE - ALL CONCRETE TO HAVE A WATER:CEMENT RATIO OF LESS THAN 0.5 AND HAVE 10% FLY ASH PORTLAND CEMENT REPLACEMENT.

FOOTINGS - ALL FOOTINGS SHALL REST ON NATIVE, UNDISTURBED SOIL AND WILL BE A MIN. OF 48" BELOW FINISHED GRADE OR IN ACCORDANCE WITH LOCAL BUILDING CODE. APPLY LIQUID APPLIED CAPILLARY BREAK (MUST DRY TACK FREE) ON TOP OF FOOTING PRIOR TO PLACING / CASTING CONCRETE FOUNDATION WALL.

STEP FOOTINGS - HORIZONTAL AND VERTICAL STEP = 24" MAX

FOUNDATION WALLS - 10" WIDE, 3000 P.S.I. AIR ENTRAINED POURED CONCRETE WITH BITUMINOUS DAMPPROOFING. FILL AND SEAL ALL TIE HOLES. BASEMENT FOUNDATION WALLS TO HAVE (2) #5 CONTINUOUS HORIZONTALLY AT TOP

Figure 1. Excerpt from BSC standard residential specification sheet

MASTERSPEC
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DIVISION 02 - EXISTING CONDITIONS			
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U 02/11	024119	SELECTIVE DEMOLITION	Demolition and removal of selected portions of buildings and site elements.
DIVISION 03 - CONCRETE			
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U 02/11	035416	HYDRAULIC CEMENT UNDERLAYMENT	Self-leveling, hydraulic-cement-based underlayment.
DIVISION 04 - MASONRY			

Figure 2. Excerpt from MasterSpec table of contents[3]

[3] More information about the MasterSpec format can be found at www.arcomnet.com/masterspec/masterspec_asc.php.

In the conventional relationship between the architect, who coordinates the work of various design professionals, and the constructor, who will execute the work either solely or through subcontracts with individual trades, both the drawing set and the specifications are organized to collect the descriptions of various parts of the building (e.g., the landscaping, the mechanical systems, and the building structure) and then convey this information to the general contractor or individual trades. The conventional system is familiar and largely effective at communicating design intent but is subject to the following limitations:

- **A balance must be maintained between the level of detail provided and the size of the documentation set.** It is generally recommended that the drawings and specifications include only the information that is actually needed for the project. Too little, of course, and important details may not be executed correctly; too much, and the set will be a burden on the many people who need to use the contract documents to complete the project.

- **Large documentation sets often include boilerplate material.** A large drawing set may actually be necessary if the project is complicated. However, large sets of drawings and specifications are often treated with suspicion because it is common to find that they are built from remnants of information from past projects. Effectively editing out information that is unnecessary will help facilitate communication.

- **Coordination must be done between drawings and specifications and between the different series of drawings (architectural, structural, etc.).** The more complicated the project is, the more important this coordination is. The architect would normally lead the effort to review all of the components and ensure that the instructions are consistent. However, because of time constraints on the project, coordination work is often not done well. In addition, in production home building environments the responsibility for coordination may lie with one or more other individuals who may or may not be well versed in all aspects of the work.

- **Fragmented information leads to problems on site.** The drawings and specifications are designed to be read together, but this is not always possible. For example, if the specifications are contained in a separate document (such as a project manual), this document may or may not make it to the construction site and so may not be available as a reference when questions arise as the work is being completed.

- **Fragmenting information by trade may not address important interactions and dependencies between the work of multiple trades or suppliers.** For whole-house systems (such as the air barrier example given above at the beginning of this section), there may not be a specific place in the conventional drawing set that draws together the information and instructions into one place. Where a lower level or no expectation of performance is given, this may not be an issue. However, in BSC's work on all types of buildings, we have found that critical information for one trade is either hidden in the information meant for another trade (requiring an intensive scanning of the entire documentation set to find) or simply not identified as having an effect or dependency on the work of others.

2.2 Cost Implications of Additional Documentation

There is an incremental cost for all of the recommendations presented in Section 2.3. Time to understand and integrate technology changes and to produce appropriate drawings typically costs money and increases the total project budget. Although the precise cost is difficult to estimate, there are two ways that an evaluation of the cost implications can be made:

Some of the recommendations fall into the category of "doing something differently" and so after an initial cost of change, it would be expected that these recommendations would become standard practice and included in the work done for the designer's normal fee. Improving specifications or improving detail drawings would be an example of improving something that is already done in a typical set of documents. Improvements made in this way are one-time costs, much as the effort required to implement building code changes in existing drawing sets: after the change is made there is typically no need for additional work.

The portion of the incremental cost that is not absorbed into the "normal" cost of documentation after the initial change can be compared to cost savings during construction of the building and cost savings during operation of the building. Framing/HVAC coordination drawings, for example, both reduce confusion and the possibility of rework on site, and as a result of careful planning at the design phase, help ensure that well-designed distribution systems are installed as designed without unplanned penetration of or interference with the thermal enclosure or ABS. These impacts are at the "subsystem" level and have not been measured. However, the broad experience of BA has shown that failure to attend to the details at this level is among the main ways in which project fail to achieve the desired performance level.

But beyond "just maintaining" the expected performance, the NIST Lab House, which is discussed in this report as a case study, gives an example of where the recommended changes to the project documentation contributed to an unexpected increase in performance. Section 3.1 describes in detail changes made to the project drawings to address the construction of the home's ABS. The intent was to create a state-of-the-art residential ABS as part of the net zero energy (NZE) objective.

For comparison, the BA airtightness target is 0.25 CFM/ft^2 of enclosure area, at –50 Pa (CFM 50/ft^2). This enclosure area includes the below grade walls and basement floor, as well as above-grade walls and roof. Depending on construction methods, BSC typically sees BA homes test between 0.13 and 0.25 CFM 50/ ft^2. BSC expected the NIST Net Zero Lab house to be tighter than this, given the continuous membrane air barrier on the sheathing, which connects directly to the foundation and wraps the walls and roof. Therefore, the specification calls for a workmanship target of 0.1 CFM 50/ft^2, which corresponds to 804 CFM 50.

The NIST Net Zero Energy Residential Test Facility (NZERTF) was measured to leak at a rate of 69 CFM at –50 Pa to outside. This is a phenomenal result, tighter than all targets set for low-energy homes. The tested leakage of the NIST house was less than one tenth of this tighter target value, or less than 3% of the BA target (see Figure 3). This result is a combination of enhanced documentation, training, and field review, of course, but the cost of these enhancements will have a direct positive effect on the actual whole-house energy savings.

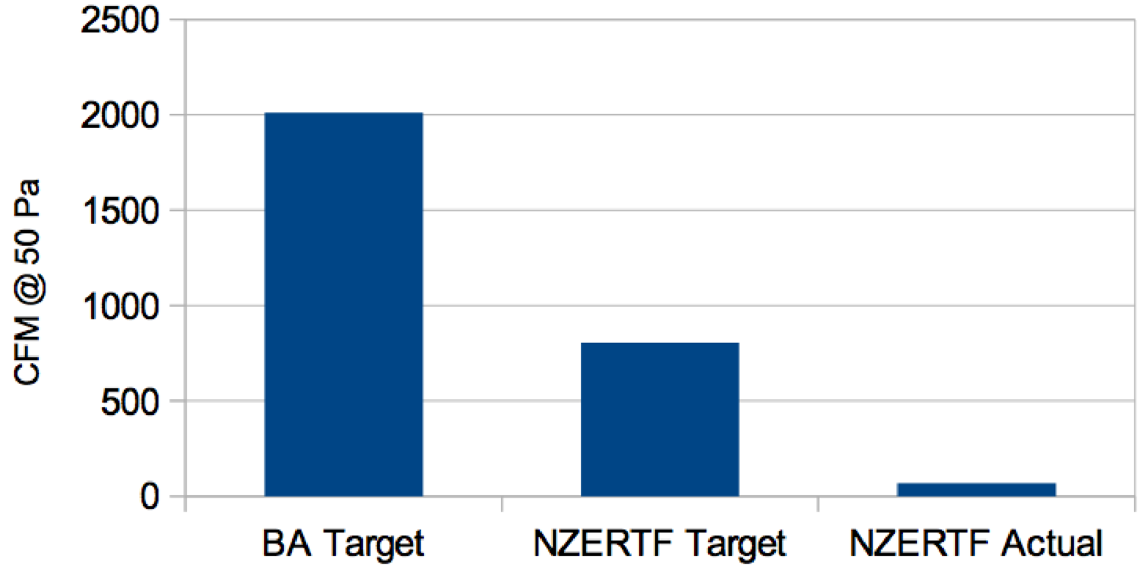

Figure 3. Preliminary enclosure airtightness test results for NIST NZERTF

2.3 Improvements for High Performance Housing

Through experience with both conventional and high performance housing, BSC has assembled the following recommendations that aim to address the issues identified above:

1. Create coordination drawings.
2. Improve specifications.
3. Improve detail drawings.
4. Review drawings and prepare quality control plan.

These recommendations relate to the contract documents. Although not discussed here, BSC also recommends an enhanced scope of training, field review, testing, and commissioning for the integration of high performance housing techniques and technologies.

Section 3 examines each of these recommendations in more detail. In each section, advice is provided for designers and builders using examples from the NIST Net Zero Energy Lab House, a recent BSC/BA project.

Sidebar: Critical Takeaways from the NIST NZERTF

Figure 4: Design Rendering of NIST NZERTF

NIST's NZERTF (see Figure 4) was constructed on the NIST campus in Gaithersburg, Maryland. The house was designed as a typical residence for a family of four in the Gaithersburg area. Through the use of a high performance enclosure and a building orientation that supports installation of a south-facing photovoltaic array, the house is designed to consume less energy than it generates on an annual basis.

As a test facility for the Building Environment Division of NIST, the residence has been designed to accommodate different types of air distribution and space heating systems, to support reconfiguration of solar thermal and photovoltaic systems, and to allow incorporation of future smart grid technologies.

During the first year after completion, the activities of a typical family of four are to be mechanically simulated using techniques developed by the NIST's Building and Fire Research Laboratory (BFRL). Once the year-long simulation has been completed, the house will be turned into a test bed for NIST's evaluation of building energy technologies and measurement science.

As a government job, the acquisition and construction processes for the project were subject to the rules for public projects. As such, the actual design and delivery processes were unlike most residential projects. The implications of this included:

- Products could not be single-sourced.
- All correspondence with the bidders was through a third party at the NIST Acquisitions Division.
- All correspondence with the general contractor was also through a third party, the NIST Contracting Officer's Technical Representative, for the project.
- It could not have been assumed that that general contractor would have any specific knowledge or experience in the construction of high performance homes.

These conditions potentially removed BSC from participation in day-to-day decisions that could impact the proper execution of the project. In anticipation of this situation, BSC included the following items in the contract documents:

- A section in the General Requirements of the Specifications for Building America Test Requirements to be verified by BSC.
- Drawings that define the Required Construction Sequence (A-501A, A-501B, A501C) that must be followed. The intent of this is to ensure that water management and airtightness strategies are implemented correctly. The sequence requires a blower door test after the ABS has been completed.
- Wall framing elevations showing all studs, headers, sheathing, and rough openings for all exterior walls and bearing walls.
- Details and installation sequences for windows, doors, and other wall penetrations.
- Exterior wall sections for each condition showing air sealing, water management, and thermal enclosure details.
- A schedule of all penetrations through the enclosure.

These drawings and specifications go into more detail than would typically be provided for this type of construction. But in this way, the information required to correctly implement the high performance enclosure of the NZERTF is presented in detail even if BSC personnel are not regularly contacted about the construction progress and so provides an excellent example of complete documentation for a high performance home.

Sidebar: Resources for High Performance Homes

- *Builder's Guides* (available for all climate zones) by Joseph Lstiburek – the builder's guides are climate-specific design and construction guides for builders of high performance homes. The house-as-a-system approach gives building science advice on house performance and specific building details. These publications are available at www.buildingsciencepress.com.

- *Building Science Digest 144: Increasing the Durability of Building Constructions.* This document offers an overview of building failures and gives an approach to durability planning. The document can be viewed online or downloaded at www.buildingscience.com/documents/digests/bsd-144-increasing-the-durability-of-building-constructions.

- *Building America Best Practices Guides.* Five climate-specific guides have been created by the U.S. Department of Energy to collect the best practice recommendations of BA. These documents can be downloaded from www.buildingamerica.gov.

- *BSC Building America Performance Criteria.* This document is maintained by BSC as a minimum performance standard for BA projects. This standard represents a performance level that is achievable to production builders with some effort. The current version of this standard can be found at www.buildingscienceconsulting.com/buildingamerica/targets.htm.

- *Building America Builder's Challenge Criteria.* This is the core standards document for the program developed by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy to challenge builders to build better housing. The standards represent a level of performance that should be very achievable for most builders. The criteria can be found at www.buildingamerica.gov/challenge/.

- IBACOS *BA High Performance Scopes of Work.* This is a model for revisions to contract documents. The document includes specific contract language and a description of a complete process for overhauling builder-trade relationships to support high performance construction. The document is available at www.ibacos.com/pubs/High_Performance_Scopes.doc.

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

3 Measure Implementation Details

3.1 Create Coordination Drawings

Managing the input of all of the design professionals often requires coordination work to identify interferences (as in the case of mechanical system distribution and structural system elements, e.g., “that duct can’t go through that beam”) and inconsistencies (e.g., “that wall finish can’t be installed with this wall assembly that is designed to dry to the interior”). Often this work is done in the office as the construction documents are being produced. Sometimes this work is done on site the first time the plans are used for construction. The latter method can lead to obvious delays, additional cost, and the associated frustration, but does mean that the people completing the work understand both the problem and the solution.

Coordination drawings are meant to ensure that the problem solving happens before construction and in a way that can be communicated to all stakeholders in the particular issue. There are several drawings that we typically create for high performance housing:

- **Site plan.** Many projects do have a site plan (with the exception of production subdivisions as noted above) but site plans are often prepared to convey only certain types of information. However, building performance can be directly affected by the site and landscaping. Energy efficiency, durability, and comfort (ventilation and solar gains) are all affected by orientation and site microclimate. A site plan that addresses shading of the house or solar panels, for example, may include the location of existing trees and structures, as well as new planting. Some green building programs may require protection of landscape, trees, etc.

- **Assembly sequence drawings.** Water management details (systems that control rainwater penetration: claddings, drainage plans, flashing, etc.), thermal control details, and air barrier details often involve several trades working in a specific sequence to properly execute the construction. BSC recommends that these critical elements be drawn out as a sequence of steps—likely in a 3-D view. This helps to ensure that the construction sequence is thought out ahead of time. It also provides a drawing that supports a discussion with trades involved in the work prior to construction. An example of this drawing is provided in Figure 5. If performance tests are required at specific stages of the work, the sequence drawing should be annotated to indicate this. For example, at the NIST project, airtightness testing was required after the exterior air barrier was completed but before any other work was started.

Example 1.1: NIST Lab House air barrier construction sequence drawings

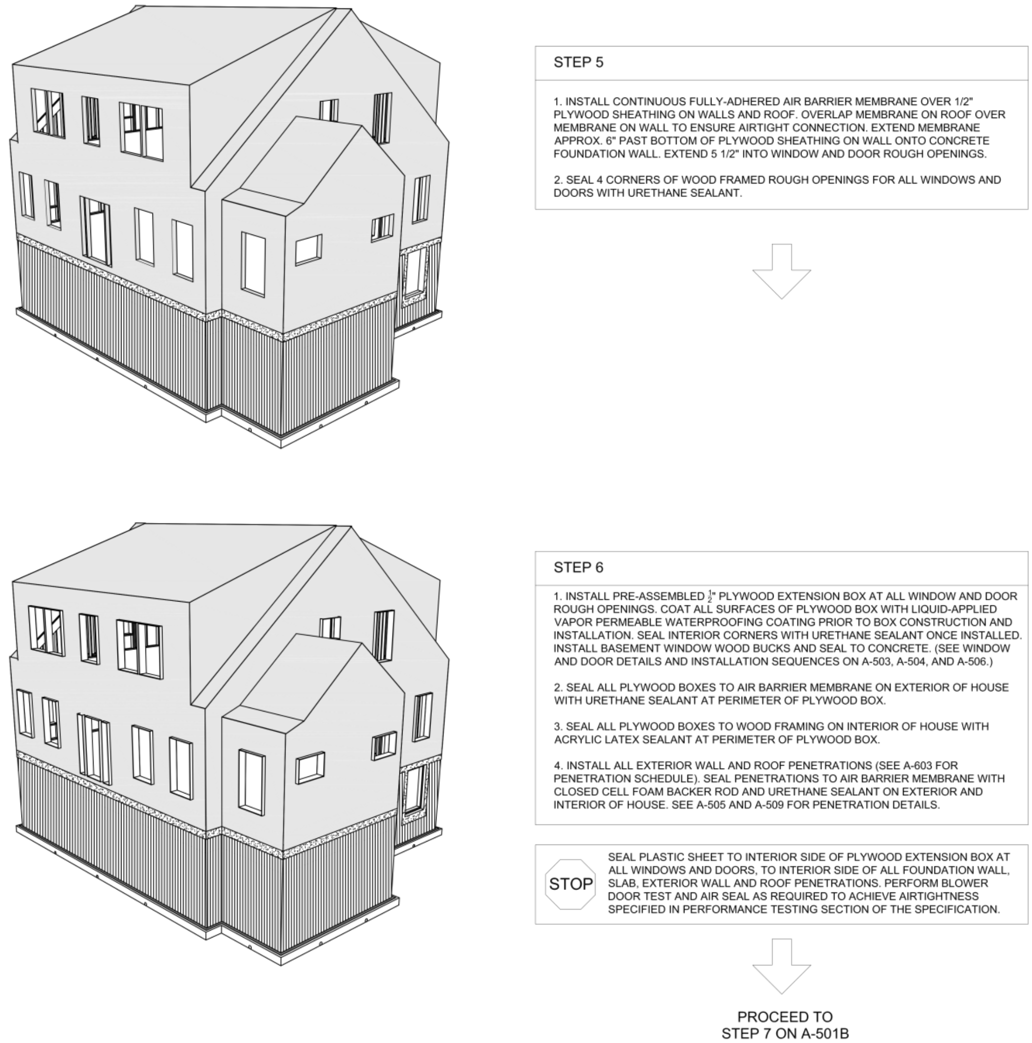

Figure 5. Partial air barrier construction sequence
(for full sequence, refer to Attachment C, Drawings A-501A, A-501B)

- **Framing layout with mechanical layout.** We frequently recommend a few strategies that can be connected with this drawing: advanced framing, compact duct distribution, stacked plumbing systems, and ductwork within the conditioned space. In addition, typical architectural elements such as ceiling height, ceiling detail, dropped soffits and bulkheads for mechanical services, “wet walls” for plumbing, and stair and skylight framing, can all be worked out on this drawing. An example of this drawing is provided in Figure 6.

Example 1.2: NIST Lab House duct coordination drawings

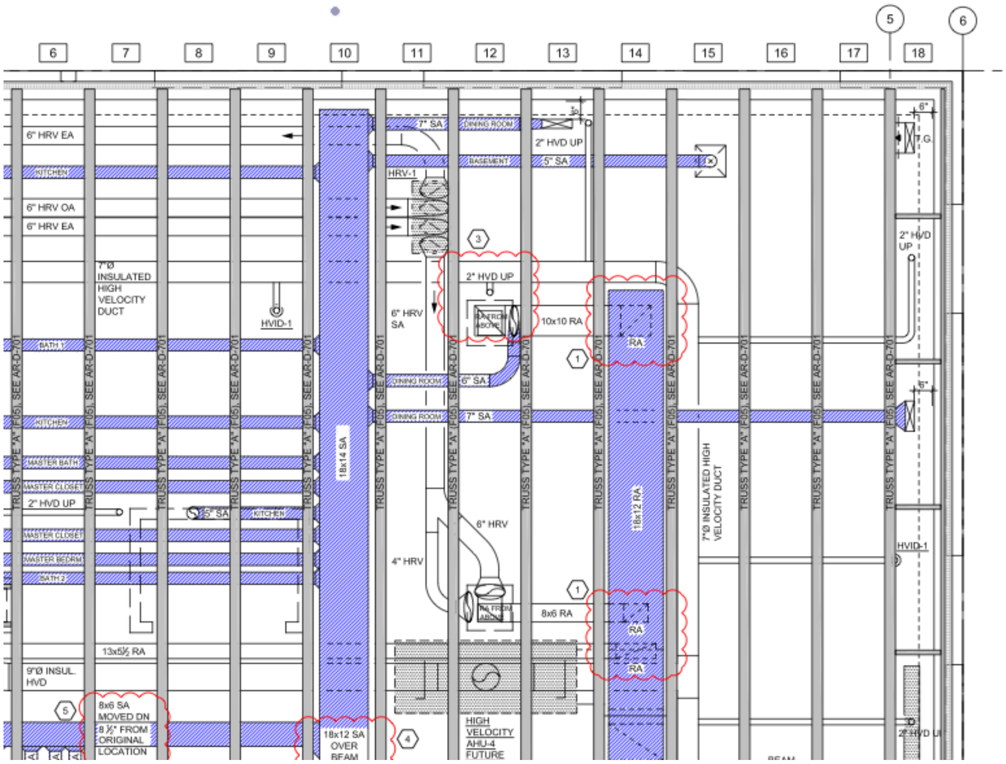

Figure 6. Partial plan of NIST floor framing and ductwork layout
(for complete plan, refer to Attachment C, Drawings: AR-D-701, AR-D-801)

- **Mechanical system equipment and distribution layout.** Some mechanical systems have straightforward and familiar equipment, but mechanical drawings sometimes ignore components (such as exhaust fans and vent or service penetration locations) or else do not clearly identify the role that the component plays in the system (ceiling fans as part of a ventilation strategy, for example). Advanced mechanical systems that provide heating and hot water, and that may also provide cooling and dehumidification or be integrated with a solar collection system, should be drawn out in detail, preferably with specific locations on the architectural plans. Equipment schedules and other information can be integrated into this drawing so that all of the relevant information is presented together. Any nonstandard requirements should also be listed on this drawing. For example, if an ENERGY STAR exhaust fan is required in the bathroom, this note—along with the ASHRAE 62.2 airflow requirement—should be placed on the drawing with the equipment label or in the mechanical equipment schedule. If third-party verification is required, this information can also be listed on the mechanical layout drawing. The intent is that the subtrades using the drawings have, in one place, all of the relevant information that is critical to the performance of the final product.

Currently BIM (building information modeling) software is being developed and deployed to assist with the coordination work described above. BIM programs allow for a significant amount of information about the building to be added into the design models and associated drawings. However, as with most modeling work, the technique depends on the experience of the user. Designers should, therefore, strive to understand the underlying technical challenges, the possible interdependencies and the type of communication that will be needed on the project. With this in hand, the best tool or combination of tools can be chosen to complete the coordination work.

In order to ensure that the enclosure meet the performance requirements needed to reach net zero during the first year following completion, as well as to support the future NIST measurement and testing, the enclosure of the building must be made as airtight as possible. Though all the required components to make the walls airtight are noted in the conventional building and wall section drawings in the construction set, this alone fails to adequately convey how a continuous ABS would be created over the exterior surfaces of the building. In particular, we realized that the construction sequencing of the exterior walls and roof was needed in order to ensure that the ABS could be applied in a continuous manner. Furthermore, once the ABS has been installed, penetrations through the air barrier need to be restricted to only what is required to complete the exterior walls (e.g., screws through attaching the furring strips to the wall framing) so that holes are not introduced into the air barrier. Although we were originally concerned with the ABS, we also needed to be sure that the process would accommodate the components needed for the structural, water management, and thermal control systems of the building enclosure.

To convey this information to the builder, we generated a set of drawings that outlines a sequence of construction to follow so this intent can be realized. This set of drawings is intended to be used in conjunction with the building section and enclosure detail drawings.

Refer to Attachment C, Drawings A-501A, A-501B.

The NIST house has a very complex system of ducts because it is designed to support three different types of heating/cooling systems, one of which is reconfigurable between supply at floor level and supply on the wall, and includes a separately ducted heat recovery ventilation system. Although this is more complicated than will be found in most home construction, high performance homes are now being built with forced air systems and mechanical ventilation systems that require careful design and layout of the ducts. For the NIST project, we developed a set of duct coordination drawings that show the contractor the intent of the design, including what bay a duct run is to be placed in within the floor/ceiling framing and how it is intended to thread through floor trusses.

Refer to Attachment C, Drawings: AR-D-701, AR-D-801.

3.2 Improve Specifications

The specifications can be improved for high performance housing in two important ways:

1. **Include a statement of intent.** High performance homes have specific performance requirements for building components and systems. In some cases, this might extend to broader requirements that address indoor air quality, the environmental impact of construction materials, or compliance with building rating standards or programs. This information should be prominently displayed as “special requirements” or “statement of intent” on the cover sheet of the drawing set, or when a formal set of specifications are prepared, under Division 00 — Procurement and Contracting Requirements and Division 01 — General Requirements. Additional, specific requirements might also be placed on

pages within the drawing set where the information is certain to be visible. For example, in California a note regarding the energy code documentation (CA Title-24) might be placed on the cover sheet and within the set, documents that list the third-party tests and verifications that are required (QII, blower door, duct testing, etc). This informs the subcontractors about additional support they will have to provide to reach the higher performance standard.

2. **Require coordination meetings**. Group training sessions with multiple trades present have been found to be a vital part of implementing high performance measures that affect the whole house (and therefore are constructed by several different trades). At group training sessions, all efforts should be made to have those who will be performing the work, as well as their supervisors and the builder's site supervision staff at hand. Plans should be made for continuous support after construction has started to ensure that learning is done "on the job." These requirements should be included under Division 00 — Procurement and Contracting Requirements and Division 01 — General Requirements.

3.3 Improve Detail Drawings

High performance building enclosures typically require more assembly detail drawings than conventional construction. Most builders and designers are familiar with the concept of "control layers" (see sidebar "Enclosure Control Layers") within the construction assembly for walls, roofs, and below-grade enclosures to address water management (drainage planes and flashings), air infiltration or exfiltration (air barriers), vapor control (vapor barriers or vapor retarders), and thermal control (insulation and airtightness). However, in typical drawing sets there are few detail drawings and those that are drawn are often not the most complicated details. In conventional construction there can be some reliance on conventional practice to address these areas. In high performance construction, the use of new materials and systems means that conventional practice cannot be trusted.

Sidebar: Enclosure Control Layers

At the most basic level, the primary function of the building enclosure is to separate the interior and exterior environments. In practice the building enclosure has to provide the "skin" to the building, i.e., not just separation but also the visible façade. Unlike the superstructure or the service systems of buildings, the enclosure is seen and is therefore of critical importance to owners, the architect, and the public. The users or occupants are concerned with both sides of the building enclosure. The appearance and the operation of the enclosure have an influence on the interior environment and on factors such as productivity and satisfaction.

In general the physical function of separation of the building enclosure may be grouped into three subcategories, as follows:

1. Support functions, i.e., to support, resist, transfer, and otherwise accommodate all the structural forms of loading imposed by the interior and exterior environments, by the enclosure, and by the building itself. The enclosure or portions of it can be an integral part of the building superstructure , usually by design but sometimes not.
2. Control functions, i.e., to control, regulate, and/or moderate all the loadings due to the separation of the interior and exterior environments , largely the flow of mass (air, moisture, etc.) and energy (heat, sound, etc.).
3. Finish functions, i.e., to finish the enclosure surfaces , the interfaces of the envelope with the interior and exterior environments. Each of the two interfaces must meet the relevant visual, aesthetic, wear and tear, and other performance requirements.

A fourth building-related category of functions can also be imposed on the enclosure, namely:

4. Distribute functions, i.e., to distribute services or utilities such as power, communication, water in its various forms, gas, and conditioned air, to, from, and within the enclosure itself.

In buildings, the enclosure control functions are often provided by control layers. Building enclosures need four principal control layers: a water control layer, an air control layer, a vapor control layer, and a thermal control layer. These control layers can be combined in one material or be separate.

Any construction detail must address the following issues:

- **Address structural connections.** Be sure to have defined a complete load transfer path, including all connections, to the ground for all loads. This means for roofs to foundations, from floors to walls to foundation and from window or canopy to walls to foundations. The most common problem noted is that of no design for connection of secondary components to the structure (e.g., windows to wall). The most common primary structural system performance problem experienced is that of too much flexibility caused by excessive slenderness.

- **Address movements and tolerances.** Design the enclosure to accommodate movements and construction tolerances. Movement joints or flexible materials should be designed and provided wherever movements could be expected. Use dry (not caulked) joints when possible. Include realistic construction tolerances and provide a design that allows for them. Movement joints must be indicated and dimensioned on drawings.

- **Maintain continuity of control layers.** The materials or systems of materials that control water, air, vapor, and heat must have continuity through each detail describing the interface or connection between enclosure assemblies and enclosure elements. The actual requirements for each of the control layers may differ depending on, for example, the rain control strategy chosen and the likely exposure to environmental loads.

- **Address construction sequence.** All of the above must be accomplished with consideration for the sequence in which the work will be completed.

- **Communicate design intent.** The intent of a detail drawing in an architectural set is to convey the designer's intent (as to function and appearance). To do this it must provide the builder, code reviewer, and suppliers with sufficient information to provide and assemble the system in the field. Hence, numerous requirements are generated from this. In practice, detail drawings missing the information below are the result of lazy or ignorant designers—ignorance is by far the most common. Not showing information on the drawings is explicitly not a defense for a designer, and has increasingly been used as evidence of incompetence in legal proceedings.

BSC offers the following advice to improve the detail drawings:

- **Draw all of the details.** Draw details at all connections between enclosure assemblies (e.g., where a roof assembly meets a wall assembly), and all changes of plane (e.g., an exterior corner or an interior corner). Common areas for enclosure details are illustrated in Figure 7.
- **Draw for communication.** Color and fills, construction sequence drawings, and 3-D isometrics are all easy to use today given computer aided drafting tools. Key detail sheets for specific trades can be printed and laminated, and then given to the trades in the field to ease the application. In some cases, the detail can only be shown clearly in 3-D, so a 2-D drawing would be inappropriate. Figure 8 shows how a window installation sequence is clearly communicated. Figure 9 shows a series of 3-D drawings that help visualize advanced framing details.

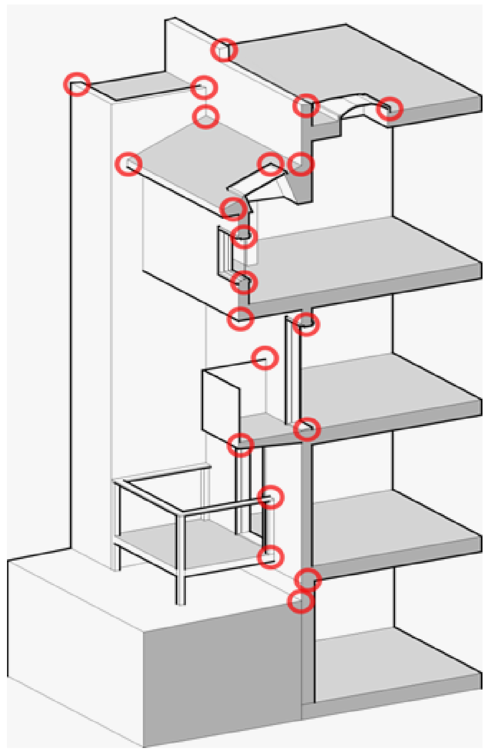

Figure 7. Common locations for required enclosure details

Example 2.1: NIST window detail drawings

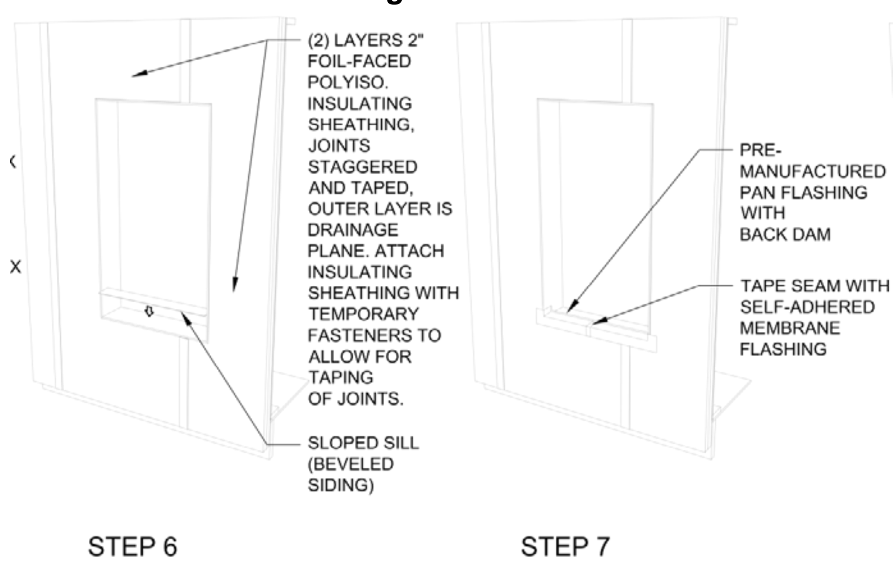

Figure 8. Partial NIST window installation sequence
(for complete sequence, refer to Attachment C, Drawing A-503)

Example 2.2: NIST advanced framing drawings

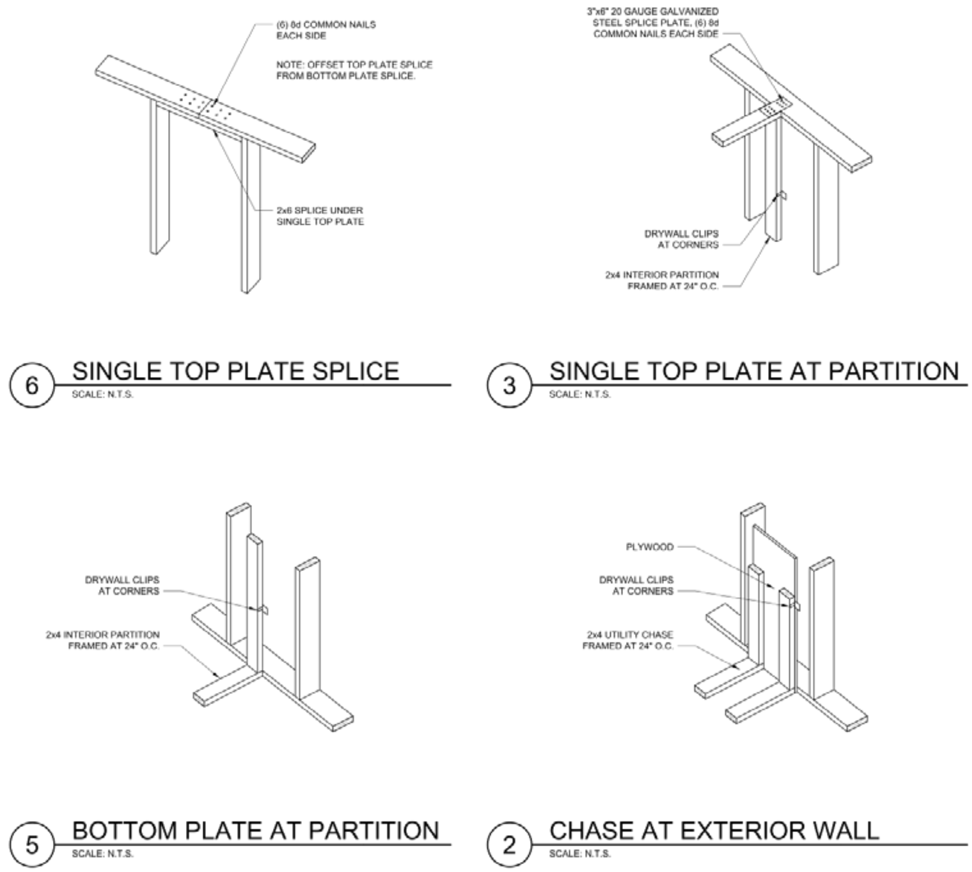

Figure 9. Selected advanced framing details
(for complete details, refer to Attachment C, Drawings: A-106 and A-502)

- **Draw realistically.** Reality should be incorporated as much as possible. Layers should be shown overlapped as they are intended to be or butted as they are intended. Computer drafting encourages drawing with unnecessary precision—layers are drawn in direct contact without drawing the thickness of the layers. Slightly exploded drawings do a better job of showing how overlaps are intended. Flashing must be shown arranged in the order intended, gaps allowed for construction (e.g., around windows) should be shown, and items such as hemmed edges, cleats, and backer rods should be clearly drawn.

- **Show key dimensions.** Dimensions of all important layers (insulation and sheathing thickness, for example) should be drawn. Screw, bolt, and nail sizes should be shown if important to the detail. Showing a projecting drip is not sufficient—a dimension should be provided if the overhang is important. Similarly, drawing a sloped roof, flashing, or ground line without labeling the intent implies that 0.01% slope is sufficient—the slope should be specified in percentages or rise:run measures. In cases where dimensions are critical, tolerance should be indicated to provide information about how precisely the dimension must be achieved. Spacing of intermittent items should be shown on the drawing.

- **Check for continuity of control layers.** Labeling the control layers is one way of keeping the function of each material clear. Figure 10 demonstrates this approach. Another approach would be to draw emphasis lines through the detail to show, for example, how the ABS function is carried by the house wrap and then the sealant and then the window unit. In any case, a simple check can be done by tracing control layers with a finger, making sure that the finger never needs to be lifted from the paper (or screen) as a line is drawn through the detail.

Example 2.3: Wall sections that identify the enclosure systems

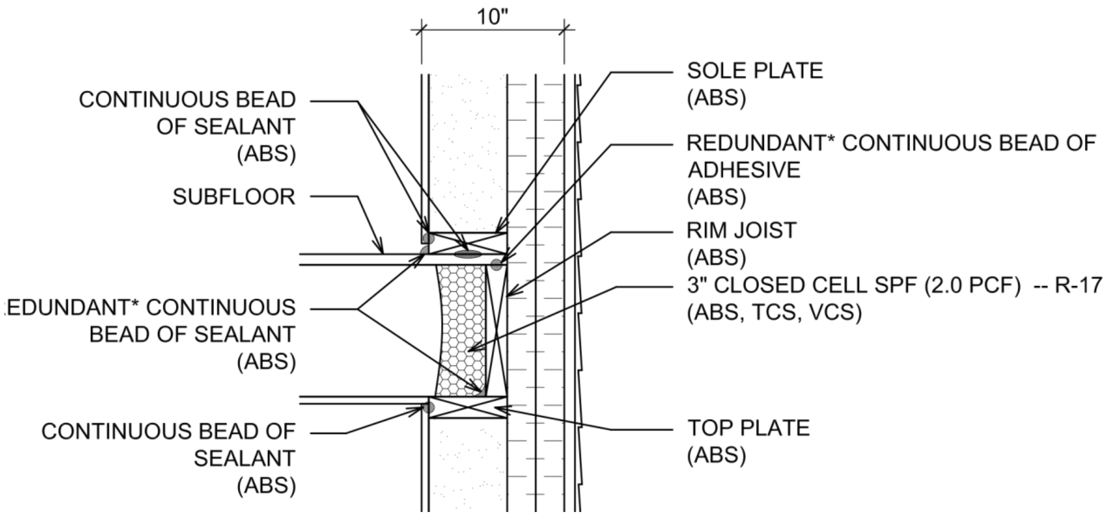

Figure 10. Partial wall section showing labeling of the ABS

Although standard 2-D exterior wall section drawings describe all of the components that are required for the construction of the wall, they do not explain the purpose of the various elements in the drawing. If the builder does not understand the purpose of an element, the element is more likely to be installed incorrectly. This can undermine the expected performance of the wall. For example, if the outer layer of exterior insulating sheathing is identified as part of the water management system, it will be understood why all seams need to be taped, and that the tape needs to be applied without any “fishmouthing” on the upper edge so that water does not get behind it. Almost every element in a wall section is part of one or more of the four enclosure systems: ABS, water management system, vapor management system, and thermal control system. To assist in providing this information to the builder, wall section drawings can include notation that indicates the enclosure system(s) to which each element belongs.

Refer to Attachment C, Drawing: HR Wall 02-3.

Correct installation of windows in a high performance home is essential because the connection between the window and the wall creates a potential weak point for three of the four of the enclosure systems of the building: thermal control, water management, and ABS. The window installation has to be integrated into each of these wall systems.

For the NIST project, the window detail sheet includes the conventional 2-D window installation details for the head, jamb, and sill. However, this sheet also includes a 3-D window installation sequence describing the steps needed during window installation to integrate the window into the wall's water management system and to continuously transition the wall's ABS to the window frame.

The initial window detail drawing that was provided with the "bid set" contained a "generic" window head, jamb and sill, because the manufacturer of the windows would not be selected until after the contract was awarded. Because the details of the selected window are so crucial in achieving the necessary water management and air control, an updated set of window details and window sequence drawings was created after the window manufacturer was selected. This updated drawing customized the installation details and sequence to be specific to the selected manufacturer's window sections and anchoring system.

Refer to Attachment C, Drawing: A-503.

Most high performance homes use some version of advanced framing (also known as optimized value engineering framing). This may include 24-om/ on center joist, stud and rafter framing, two-stud corners, no headers at doors and windows in non-load bearing walls, and minimized framing at doors and windows in bear walls. As this is still not a standard construction technique, exterior wall framing elevation drawings are included in the NIST construction set showing the implementation of the advanced framing techniques for the construction. In addition, a sheet with 3-D drawings illustrating the general techniques is included with the drawing set.

Refer to Attachment C, Drawings: A-106 and A-502.

3.4 Review Drawings and Prepare Quality Control Plan

Both the architectural designer and the builder's construction team should review the completeness of construction drawings prior to construction. This may seem like an obvious requirement, but, as discussed, instructions to trades are often incomplete, inconsistent, and consequently, ignored. Because high performance homes often include building systems that are installed by multiple trades, review of the design intent, proposed methods, and required performance is critical. The following recommendations focus on the building enclosure and the mechanical systems as key components of a high performance home.

Any drawing review should incorporate the following general points (given in order of most general to most specific):

1. **All required drawing information is provided.** This is a blanket statement but is meant to indicate that the first step (particularly for an internal review) should be a review of the basics. Figure 11 shows a sample from an excellent Canadian document that could be adapted for this purpose.

2. **All major enclosure assemblies are specified.** At a minimum, the enclosure layers should be given as a list that includes both the material and its enclosure control function (water control, air control, vapor control, thermal control) and preferably drawn. If a formal set of specifications is used on the project, cross referencing the enclosure layers with the appropriate specification sections may be appropriate.

9. <u>WALL SECTIONS</u>

9.1 Show all the foundation walls, footings, pile caps, beams, etc.

9.2 Relate all the steel beams, lintels, etc., that occur in the wall sections to datum lines such as the finished floor or general top of steel.

9.3 Note all the floor-to-floor heights, the window-sill heights above the floor, etc.

9.4 Indicate, using structural drawings, which walls are to receive masonry ties and which are to receive other types of reinforcing.

9.5 Indicate weep holes in any walls built to the rain-screen principle and call the appropriate spacing.

9.6 Clearly show all damp-proof masonry courses and masonry metal flashing.

9.7 Ensure that proper insulation values have been met for all exterior construction.

9.8 Check the indication of subgrade drains and the sloping of the finish grade. Slope the finish grade away from the buildings.

9.9 Make sure that the exterior wall insulation and air barrier are continuous

Figure 11. Excerpt from "Building Practice Note 29: Building Drawings Checklist: Architectural Drawings"[4]

3. **The enclosure control functions for each layer in each assembly are clearly identified.** A draft BSC review tool that was developed for this purpose is included as Attachment A. The primary intent of this screening tool is to identify building enclosure assemblies, which by design clearly illustrate their ability to minimize damage caused by moisture, the dominant premature failure mode for building components. Where assemblies do not meet checklist items, it is anticipated that the design team will modify the design or illustrate compliance through calculation, analysis, testing, or modeling. The functional analysis will assist the design team in selecting enclosure assemblies that are more likely to provide acceptable control of water, air, vapor, and heat flow, but actual performance will be determined by a range of factors that are not addressed by this checklist.

4. **Specifications for enclosure systems match the required building performance specifications.** Consider, for example, the specification for the thermal performance of the enclosure and the many components required to ensure that performance. The review should evaluate the choice of materials, systems, and equipment relative to the whole building performance objectives.

[4] Strelka, C.S. “Building Drawings Checklist: Architectural Drawings” *Building Practice Note 29*. Division of Building Research, National Research Council Canada. Ottawa, August 1982.

5. **Details are drawn for all critical interfaces and junctions.** (See recommendations in Section 2.)

6. **Appropriate materials are specified for control functions and are compatible with adjoining or connected materials or systems**. This task requires some knowledge of chemical compatibility of the specified materials as well as an understanding of the movements and tolerance that the particular detail must address. A useful starting point for any material or system is to examine the manufacturer's instructions and recommendations.

A more detailed review might include:

- Review energy model assumptions and results.
- Review design basis for structural, mechanical, and electrical systems.
- Review enclosure assembly design.
- Review the expected service life of major components relative to the design service life for the building.

An important function of the drawing review is to identify specific details or construction sequences that will need special attention as they are constructed. A list of these issues should be made and discussed with the construction crew and construction supervision team.

If warranted, quality control checklists should be developed for each project or building system design. However, it should be noted that quality control checklists are rarely effective substitutes for knowledgeable and diligent review by the design and construction manager. Attachment B includes the Building America Quality Control Checklist, which has been developed by BSC as both a guide to assist in the transition to high performance home building, and as a simplified tool to be used as part of any builder's on-site quality control procedures. There are two parts to this document: the checklist and the resource appendix.

The checklist contains the most critical points that should be verified during the construction of a high performance house. The checklist is not intended to be a substitute for good design and good workmanship, but should be a common point of reference and part of a minimum standard of quality for high performance construction.

The overall checklist is divided into a pre-drywall inspection and a final inspection. These two points correspond to the verification steps in many common energy efficiency programs. Each of the checklist divisions is further subdivided to more closely correspond to typical phases of the construction process.

It is anticipated that the quality control checklist will be modified by the project team based on the results of the drawing review to suit the specific quality control needs of the project.

Attachment A: Building Enclosure Functional Checklist

Building
Science
Corporation

BUILDING ENCLOSURE FUNCTIONAL CHECKLIST

Version 1.2 – July 2011

Overview

The primary intent of this checklist to identify building enclosure assemblies, which by design clearly illustrate their ability to minimize damage caused by moisture, the dominant pre-mature failure mode for building components. Where assemblies do not meet checklist items it is anticipated that the design team will modify the design or illustrate compliance through calculation, analysis, testing, or modeling. Complete and document the following checklist for each enclosure assembly. The functional analysis will assist the design team in selecting enclosure assemblies that are more likely to provide acceptable control of water, air, vapor and heat flow but actual performance will be determined by a range of factors that are not addressed by this checklist.

Detailed Drawings and Specifications

1. Do each of the enclosure assemblies listed on the wall and roof schedule(s) identify the materials or systems intended to provide rain water, air, vapor, and thermal control? ☐
2. Are appropriately scaled detail drawings (plan and section view) showing the continuity of the rain water, air, vapor, and thermal control layers provided for all of the interfaces including those identified in **Figure 1** below? ☐
3. Are specifications provided outlining; ☐
    a. Approved materials, equivalence or performance requirements,
    b. Quality Control requirements,
    c. Testing requirements (manufacturer and field)

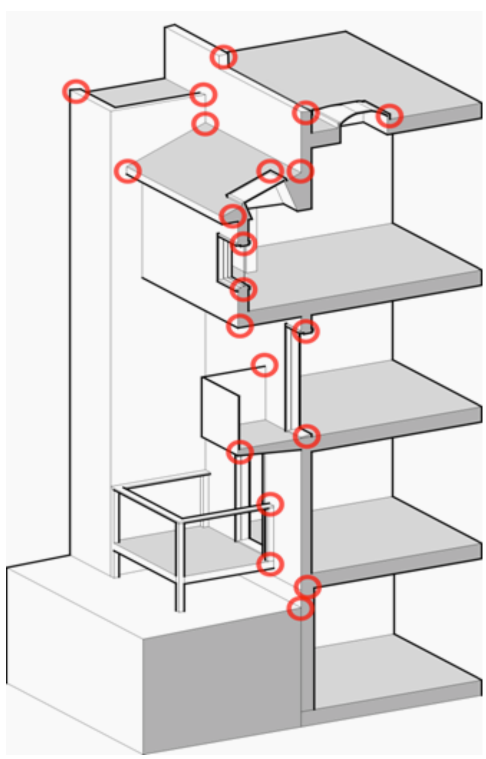

Figure 1: Common Locations for Required Details

Rain Water Control

1. Are rain water control layer components installed with a positive slope to allow drainage to the exterior? ☐
2. Is the rain water control layer shown as continuous on all details through transitions between assemblies (roof-wall) and components (wall-glazing)? ☐
3. Is the rain water control layer protected from sunlight at all points except intentionally protruding flashings made of an appropriately durable material? ☐
4. Is the rain water control layer protected from thermal expansion and contraction by either being located on the inside of thermal control layer or being detailed with appropriate transition materials to accommodate for movement of the structure(s)? ☐
5. Is the rain water control layer on the outside of the building structure? ☐
6. Do all of the materials specified for the rain water control layer meet building code requirements? ☐
7. Is the back of the cladding drained at all points (i.e., provision of a capillary break) so that water cannot build up head between the cladding and the water control layer? ☐
8. Is the water control layer part of a manufactured system? If not, is it chemically compatible with other materials in the system? ☐
9. Is the expected service life greater than that of the outer lying components? ☐
10. Are all of the openings for windows, doors and other penetrations of the enclosure flashed and drained to the exterior? ☐

Air Control

1. Do the air barrier specification meet the GSA/NIBS standard? ☐
2. Is the primary air control layer shown as continuous on all details through transitions between assemblies (roof-wall) and components (wall-glazing)? ☐
3. Is the primary air control layer protected from sunlight at all points? ☐
4. Is the primary air control layer protected from thermal expansion and contraction by being located on the inside of thermal control layer and have allowance for movement of the structure(s)? ☐
5. Is the air control layer a stiff material or adequately supported to avoid billowing and damage due to design wind events? ☐
6. Is the air control layer part of a manufactured system? If not, is it chemically compatible with other materials in the system? ☐
7. Is the expected service life greater than that of the outer lying components? ☐

Vapor Control

1. Is the assembly vapor open in at least one direction to allow drying? ☐
2. If an absorptive cladding (e.g., masonry, concrete or stucco) is used, is either a ventilated space included behind the cladding or vapor control layer located outside of the rain water control layer? ☐

Thermal Control

1. Is the thermal control layer shown as continuous on all details through transitions between assemblies (roof-wall) and components (wall-glazing)? ☐
2. Is the thermal control layer protected from sunlight at all points? ☐
3. Is the thermal control layer on the outside of the building structure? ☐
4. Is the thermal control layer tolerant of moisture accumulation for damage and performance degradation? ☐
5. Does the thermal control layer have adequate thermal conductance at all points to meet building code requirements and avoid surface condensation? ☐
6. Is the space not humidified and positively pressurized? ☐

Glossary

Rain Water Control Layer - The rain penetration control layer is the continuous layer (comprised of one of several materials and formed into planes to form a three dimensional boundary) in an enclosure assembly that is designed, installed, or acts to form the rainwater boundary.

Air Control Layer - The air control layer system is the primary air enclosure boundary that separates indoor (conditioned) air and outdoor (unconditioned) air. In multi-unit/townhouse/apartment construction the air control layer system also separates the conditioned air from any given unit and adjacent units. Air control layer systems also typically define the location of the pressure boundary of the building enclosure. In multi-unit/townhouse/apartment construction the air control layer system is also the fire barrier and smoke barrier in inter-unit separations. In such assemblies the air control layer system must also meet the specific fire-resistance rating requirement for the given separation.
Air control layer systems typically are assembled from materials (such as gypsum board, sealant, etc.) incorporated in assemblies (such as walls, roofs, etc.) that are interconnected to create enclosures. Each of these three elements has measurable resistance to airflow. The maximum air permeances for the three components are listed as follows:

- Material 0.02 l/(s-m2)@75 Pa
- Assembly 0.20 l/(s-m2)@75 Pa
- Enclosure 2.00 l/(s-m2)@75 Pa

Materials and assemblies that meet these performance requirements are said to be air control layer materials and air control layer assemblies. Air control layer materials incorporated in air control layer assemblies that in turn are interconnected to create enclosures are called air control layer systems. Note that sometimes assemblies can meet the assembly requirements without using materials that meet the material requirement. And sometimes enclosures can meet the enclosure requirements without meeting either the material or assembly requirements. Materials are tested according to ASTM E 2178 or E 283. Assemblies are tested according to ASTM E 2357. Enclosures are tested according to ASTM E 779 or CAN/CGSB – 149.

Vapor Control Layer - The component (or components) that is (or are) designed and installed in an assembly to control the movement of water by vapor diffusion. One of several vapor control classes: The measure of a material or assembly's ability to limit the amount of water that passes through the material or assembly by vapor diffusion. The test procedure for determining vapor control layer class is ASTM E-96 Test Method A (the desiccant or dry cup method).

Class I: Materials that have a permeance of 0.1 perm or less.
Class II: Materials that have a permeance of 1.0 perm or less and greater than 0.1 perm
Class III: Materials that have a permeance of 10 perms or less and greater than 1.0 perm

Thermal Control Layer - The component (or components) that is (or are) designed and installed in an assembly to control the transfer of thermal energy (heat). Typically these are comprised of insulation products, radiant barriers, or trapped gaps filled with air or other gases. One quantitative measure of a thermal control layers resistance to heat flow is the R-value. R-values are limited in that they deal with conduction, one of three modes of heat flow (the other two being convection and radiation) and that their range of applicability is typically limited to materials not assemblies.

Attachment B: BSC Building America Quality Control Checklist

BSC Building America Quality Control Checklist

version 1.0 - October 3, 2008

INCLUDED IN THIS PACKAGE

- How to use the the BSC Building America QC Checklist
- Checklist Part 1: Pre-drywall Inspection
- Checklist Part 2: Finish Inspection
- Resource Appendix with BSC Information Sheets

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Building America®
U.S. Department of Energy
Research Toward Zero Energy Homes

How to use the BSC-Building America QC Checklist

The Building America Quality Control Checklist has been developed by Building Science Corporation as both a guide to assist in the transition to high performance home building, and as a simplified tool to be used as part of any builder's on-site quality control procedures.There are two parts to this document: the checklist and the resource appendix.

The Checklist

The checklist contains the most critical points that should be verified during the construction of a high performance house. The checklist is not a substitute for good design and good workmanship but can be a common point of reference and part of a minimum standard of quality for high-performance construction.

The overall checklist is divided into a pre-drywall inspection and a final inspection. These two points correspond to the verification steps in many common energy efficiency programs. The each of the checklist divisions is further subdivided to more closely correspond to typical phases of the construction process.

The Resource Appendix

In the attached appendix, some of the checklist items are explained in more detail. While it is not possible to address every conceivable construction detail, common situations and the applicable building science principles are explained with helpful graphics, photographs, references to common building codes, and our suggestions for other electronic and printed resources that can be used for further research.

The appendix is divided into a series of short information sheets, each addressing one of the checklist items, which allows you to assemble packages of information for specific trades or construction phases.

The Building America Quality Control Checklist should be used at five key parts of the construction process.

Design

At the house design stage, the checklist can be used to assess the readiness of drawings prior to contract negotiations. The checklist and appendix also serves as a resouce for designers during detailing and material selection.

Contract Negotiation

During contract negotiation, the Checklist provides a clear, concise means of outlining the what work needs to be done to achieve performance targets like the BSC BA Minimum Performance Specification. The Checklist can be used as a short form of the BA High Performance Scopes of Work. The Checklist list should be discussed during negotiations and included in contract and scope of work documents.

Training

Conduct trade group meetings as recommended by the "BSC 7-Steps to High Performance Housing" document (www.buildingscience.com/QA). The QC Checklist is an important part of this meeting - use it to facilitate discussion between site supervision and all trades and crews with overlapping work by walking through construction steps and checklist verification points. The Checklist can be divided into sections. Use each Checklist section and the referenced Information Sheets in the Resource Appendix as handout information to each trade crew.

On-site Verification

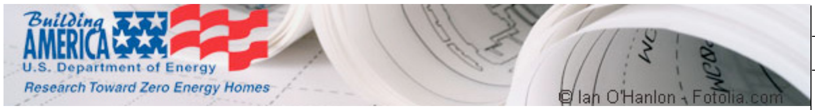
Give the checklist to both site supervision and trades. Everyone should have access to the same information about what is expected. During construction, the checklist is to be completed by the site supervisor. BSC recommends that digital photographs be taken to document checklist items as construction proceeds. The site supervisor should work to integrate the recommended verifications into their daily routine.

Buyer Assurance

The completed checklist is a confirmed record of the high quality of your construction. This record can be offered to the homebuyer as an important assurance of quality. Include the completed checklist in a homeowner manual that contains other important documents about the house and its systems.

Building Science Corporation will update this checklist from time-to-time. To make sure that you have the most up-to-date version, please check the quality assurance page on our website:

www.buildingscience.com/QA



BSC Building America Quality Control Checklist

Builder Name:	
Project:	
Lot Number:	

Part 1 - Pre-drywall Inspection

Foundations

		Completion Verified
A drainage plane must be provided with sub-grade drainage for below grade spaces	ref: BSC Information Sheet 101	☐
Exterior or interior perimeter footing drainage system is installed		☐
Drainage membrane or draining insulation is installed around below grade walls		☐
Free-draining backfill is installed over perimeter drainage		☐
Sub-slab gravel bed is connected to perimeter drainage		☐
Perimeter drainage is connected to storm water drain or sloped to daylight		☐
A capillary break separating the entire foundation from the soil must be provided	ref: BSC Information Sheet 101	☐
A below-slab capillary break has been installed		☐
A capillary break has been installed on the foundation wall and footings (horizontal and vertical surfaces)		☐
Use soil gas resistant construction techniques	ref: BSC Information Sheet 110	☐
Floor openings, concrete joints, and foundation checks have been sealed against gas entry		☐
Floor drains and sumps have been sealed against gas entry		☐
Passive vent stack with "T" in sub-slab gravel bed has been installed		☐

Pre-Cladding

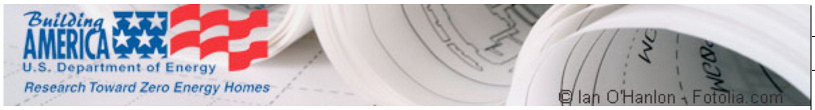
		Completion Verified
Protect construction materials from moisture before installation	ref: n/a	☐
Keep all building materials dry during storage on-site		☐
Separate wood from concrete or masonry with appropriate capillary break	ref: n/a	☐
Sill plates separated from foundation wall with capillary break		☐
A drainage plane must be provided that is integrated with flashings	ref: BSC Information Sheets 300, 302	☐
Drainage plane has been installed in a continuous manner		☐
Sheet material has been properly lapped to drain water		☐
All flashing elements specified have been correctly installed		☐
Drainage plane overlaps flashing or connected by a transition membrane		☐
Drainage holes and through-wall flashing have been provided at brick seat		☐
A drainage plane must be accompanied by a drainage space	ref: BSC Information Sheet 300	☐
Materials to create drainage gap have been installed as specified		☐
Intentional drainage spaces are clear of construction debris		☐
Subsill flashing: windows and doors must be "pan-flashed"	ref: BSC Information Sheet 301	☐
All windows and door openings are "pan-flashed"		☐
Pan-flashing installed with end dams and positive slope towards the exterior		☐
Flashing materials are correctly lapped		☐
Reservoir claddings must be "uncoupled" from wall assemblies	ref: BSC Information Sheet 304	☐
Reservoir claddings (such as brick, stucco and fiber cement) are back-ventilated with min. 1/4" ventilation space (1" for brick) or are installed over a moisture-tolerant and vapor impermeable material		☐
A continuous air barrier must be provided	ref: BSC Information Sheets 403, 404, 405, 406	☐
Air sealing provided between bottom plates and floor deck		☐
Rim joists areas are caulked or sealed with sprayed foam		☐
Carrying beams running to outside walls and beam pockets are sealed		☐
Perimeter of windows and doors are sealed on the interior side with low-expansion foam or sealant		☐
Bathtubs on exterior walls have draftstopping materials installed behind tub		☐
Fireplace enclosures have draftstopping material installed to line enclosure		☐
Cantilevered floors (including floors over attached garages) are sealed with spray-foam or sealant as appropriate		☐
Bay and Bow Windows are sealed		☐
Walls and ceilings separating attached garages from living space are properly sealed by: installing gas-proof membrane, taping gypsum board, and sealing all penetrations		☐
Chimney chases and interior soffits running to exterior walls have been draftstopped and air sealed		☐
Electrical wiring or outlets on exterior walls and other penetrations have been sealed		☐
Only airtight-rated recessed lights installed in insulated ceilings		☐
Vapor control of wall, roof and foundation assemblies must be provided as specified	ref: BSC Information Sheet 311	☐
Materials with vapor permeability characteristics matching the products specified for each assembly in the construction documents have been installed		☐

Pre-insulation

		Completion Verified
Wet rooms should have floor drainage	ref: BSC Information Sheet 305	☐
Floor drainage installed in bathrooms and showers		☐
Floor drainage installed in laundry rooms		☐
Floor drainage installed in mud rooms		☐
Install floor drain and drain pan where water heater is installed over living space		☐
Paper faced gypsum board should not be used in multi-family party walls or any part of the building constructed before the roof is applied	ref: n/a	☐
Plumbing should not be located in exterior walls	ref: n/a	☐
Make plumbing easy to inspect and repair and insulate plumbing pipes to keep them warm (above dewpoint temperatures)	ref: BSC Information Sheet 305	☐
Access panels for plumbing inspection have been installed where specified on plans.		☐
Pipe insulation has been installed on exposed hot and cold runs not located in walls.		☐

Pre-drywall

		Completion Verified
Install insulation to meet HERS Insulation Installation Grade 1	ref: BSC Information Sheet 501	☐
Few installation defects, only very small gaps around wiring, electric outlets, etc. and incomplete fill amounts to 2% or less. Gaps running clear through the insulation amount to no more than 2% of the total surface area covered by the insulation. Wall cavity insulation is enclosed on all six sides and in substantial contact with the sheathing material on at least one side (interior or exterior) of the cavity.		☐
ENERGY STAR Thermal Bypass Inspection Checklist has been completed		☐



BSC Building America Quality Control Checklist

Builder Name:	
Project:	
Lot Number:	

Part 2 - Finish Inspection

Mechanical System Inspection

		Completion Verified
Sealed Combustion Equipment	ref: BSC Information Sheet 601	☐
Sealed combustion equipment provided as specified		☐
Sealed combustion equipment installed as specified		☐
Ventilation system design must have the capacity to meet the requirements of ASHRAE 62.2 and must be commissioned at 60% of ASHRAE 62.2	ref: BSC Information Sheet 610	☐
Ventilation system provided and installed as specified		☐
Ductwork to inside and outside are properly installed and connected		☐
Ventilation system control has been installed and commissioned as specified		☐
Air filter housings must be airtight to prevent bypass or leakage		☐
Interior spaces must be air pressure balanced (less than 3 Pascals between all spaces). Transfer grilles or jump ducts to be provided for any closed room without a return grille (except bathrooms, closets, pantries and laundry rooms)	ref: BSC Information Sheets 604	☐
Transfer grilles have been installed where indicated on the plans		☐
Duct systems properly sized and placed	ref: n/a	☐
Duct runs are placed where indicated on the drawings or layout has been revised with mechanical designer		☐
Conditioning system design loads must be determined according to ACCA Manual J and equipment must be sized using ACCA Manual S	ref: n/a	☐
Air conditioning system supplied and installed as specified		☐
Part load dehumidification must be provided in IRC Zones 1 and 2 (“Hot-Humid Climates”) for buildings and units less than 2000 square feet	ref: BSC Information Sheet 620	☐
If included in the design, part-load dehumidification system has been provided and installed as specified		☐
Dehumidification system controls have been installed and commissioned as specified		☐
Ducts should be located inside the enclosure air barrier.	ref: BSC Information Sheet 602	☐
If located outside, leakage must be limited to 5% of the total air handling system rated air flow at high speed (nominal 400 CFM per ton) determined by pressurization testing at 25 Pa.		☐
Building cavities not used as part of the forced air supply or return system		
Supply and return ductwork sealed to be airtight	ref: BSC Information Sheet 603	☐
Ductwork has been air sealed at joint locations and equipment connections		☐
Ductwork is sealed to supply and return boots		☐
Protect ductwork during construction	ref: n/a	☐
Ductwork rough-in protected from construction debris		☐
Supply and return duct boots have been covered during interior finishing		☐
Exhaust vents and intake ducts correctly placed	ref: BSC Information Sheet 606	☐
Exhaust and intake ducts installed where indicated on plans		☐
Clothes dryers vented outdoors		☐

Landscaping

		Completion Verified
Provide strips around buildings free of planting and organic mulch	ref: n/a	☐
A 24" wide strip free of organic mulch and planting has been provided around buildings		☐
Bushes and trees are at least 36" away from building		☐
Site surface water is controlled by appropriate grading and landscape measures	ref: BSC Information Sheet 101	☐
Grade on all sides of building slopes away from building		
Patios and decks are installed lower than the finished floor and slope away from the building		☐
Garage floor is lower than the finished floor and slopes away from the building		☐
Driveway is lower than garage floor and slopes away from the building		☐
Finished grade is lower than main floor and slopes away from the building		☐
Stoops, porches and walkways are lower than the main finished floor and slope away from the building		☐

Exterior Finish

		Completion Verified
Separate wood from concrete or masonry with appropriate capillary break	ref: n/a	☐
Deck and stair posts held off concrete with metal brackets or other non-organic spacer		☐
Detail deck to house connection (including ledger to wall connection) to shed water away from house and to allow natural drying of assembly		☐
Install exterior flashing and drainage	ref: BSC Information Sheet 302	☐
Step flashing at all roof/wall intersections and terminated with "kickout" flashing or overhang		☐
Gutters and downspouts or other roof drainage system has been installed		
Select building materials that are insect resistant (steel framing, concrete framing, treated wood framing and sheathing, plastic or plastic composite cladding, cement or fiber cement cladding, brick or stucco cladding)	ref: n/a	☐
Insect resistant materials are installed where specified on the plans		☐

Pre-occupancy

		Completion Verified
Paper faced gypsum board should not be used in “wet areas”	ref: BSC Information Sheet 407	☐
Paper-faced gypsum board not used in bathrooms, showers, laundry rooms and mudrooms		☐
Raise gypsum board minimum of 1/2" above concrete slab		☐
An environmental separation between attached garages and living space must be provided, no air handling equipment located in garage	ref: BSC Information Sheet 305	☐
Walls and ceilings separating attached garages from living space are properly sealed by: installing gas-proof membrane, taping gypsum board, and sealing all penetrations		☐
Washers should be equipped with single throw shut off valves	ref: BSC Information Sheet 305	☐
Washing Machine connections are equipped with a single throw shut off valve		☐
No carpet in areas prone to get wet: bathrooms, laundry rooms, kitchens, and entryways	ref: BSC Information Sheet 305	☐
No carpet has been installed in bathrooms, laundry rooms, kitchens, and entryways		☐
Vapor open design of construction assemblies maintained	ref: BSC Information Sheet 311	☐
Vapor-permeable finish materials that do not interfere with vapor open design have been installed		☐

Resource Appendix

This appendix contains Building Science Information Sheets that provide more information for specific inspection points on the BSC Building America Quality Control Checklist. Each Information Sheet is a one or two page document that can easily be printed for use on site or attached to a trade scope of work or contract. The most current version of these document, and other building science information, can be found at www.buildingscience.com/QA

Foundations and Site Work

101 Groundwater Control
110 Soil Gas Control

Water Management and Vapor Control

301 Drainage Plane
302 Pan Flashing for Exterior Wall Openings
303 Common Flashing Details
304 Integrating Deck Ledger Board with Drainage Plane
305 Reservoir Claddings
306 Interior Water Management
311 Vapor Open Assemblies

Air Barriers

404 Air Sealing and Framing
405 Air Sealing Enclosure Penetrations
406 Air Sealing Windows
407 Air Barriers - Tub, Shower and Fireplace Enclosures

Thermal Control

501 Installation of Cavity Insulation
511 Basement Insulation
512 Crawlspace Insulation
513 Slab Edge Insulation

HVAC, Plumbing and Electrical

601 Sealed Combustion
602 Ducts in Conditioned Space
603 Duct Sealing
604 Transfer Ducts and Grills
606 Placement of Intake and Exhaust Vents
610 Ventilation System
620 Supplemental Humidity Control

Attachment C: Sample Drawings from the NIST Zero Energy Residential Test Facility

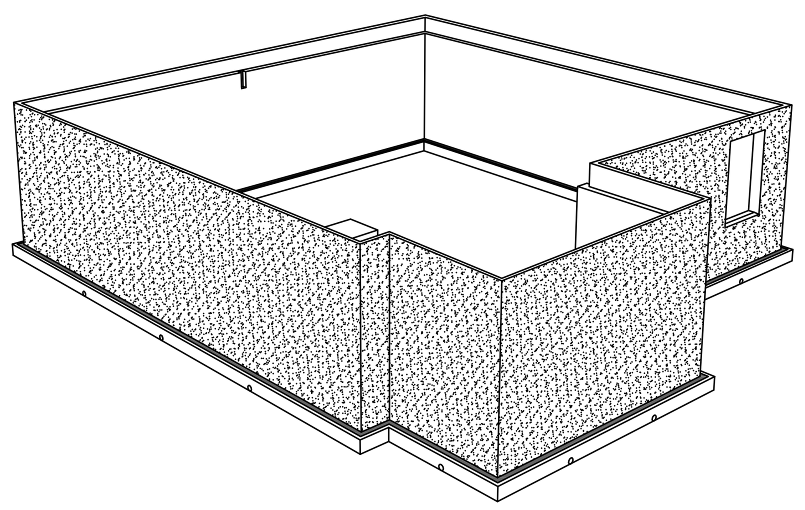
SEQUENCE NOTES

1. THE FOLLOWING CONSTRUCTION SEQUENCE LISTS THE REQUIRED ORDER OF STEPS TO BE COMPLETED TO ACHIEVE THE WATER MANAGEMENT AND AIRTIGHTNESS GOALS OF THIS PROJECT. IT IS THE RESPONSIBILITY OF THE GENERAL CONTRACTOR TO COORDINATE AND SCHEDULE ALL CONSTRUCTION ACTIVITIES TO ACCOMMODATE THIS CONSTRUCTION SEQUENCE.

2. GARAGE AND BREEZEWAY CONSTRUCTION TO FOLLOW THIS CONSTRUCTION SEQUENCE AS APPLICABLE. HOWEVER, GARAGE AND BREEZEWAY ARE PERMITTED TO BE CONSTRUCTED AFTER HOUSE CONSTRUCTION HAS BEGUN AS LONG AS THE FOLLOWING STEPS ARE COMPLETED: 1) BREEZEWAY CONCRETE SLAB AT HOUSE TO BE INSTALLED AT STEP 15 ALONG WITH PORCH CONCRETE SLABS OR LATER, AND 2) BREEZEWAY ROOF LEDGER FRAMING TO BE INSTALLED AT STEP 16, ON TOP OF INSULATING SHEATHING AND BEFORE FURRING STRIPS. NOTE: AIRTIGHTNESS PERFORMANCE TESTS NOT PERFORMED ON GARAGE.

3. ALL CONCRETE SLAB AND CONCRETE FOUNDATION WALL PENETRATIONS MUST BE CAST INTO THE CONCRETE. PENETRATIONS SHALL NOT BE CREATED AFTER THE CONCRETE HAS BEEN PLACED. SEE A-603 FOR PENETRATION SCHEDULE.

4. ALL EXTERIOR WALL AND ROOF PENETRATIONS MUST BE INSTALLED DIRECTLY AFTER THE AIR BARRIER MEMBRANE HAS BEEN INSTALLED. PENETRATIONS SHALL NOT BE INSTALLED AFTER THE INSULATING SHEATHING HAS BEEN INSTALLED. SEE A-603 FOR PENETRATION SCHEDULE.



STEP 1

1. CAST PVC DRAIN PIPE INTO BOTTOM OF CONCRETE FOOTING. CONCRETE COLUMN FOOTINGS TO BE PLACED AT SAME TIME AS FOUNDATION WALL FOOTINGS.

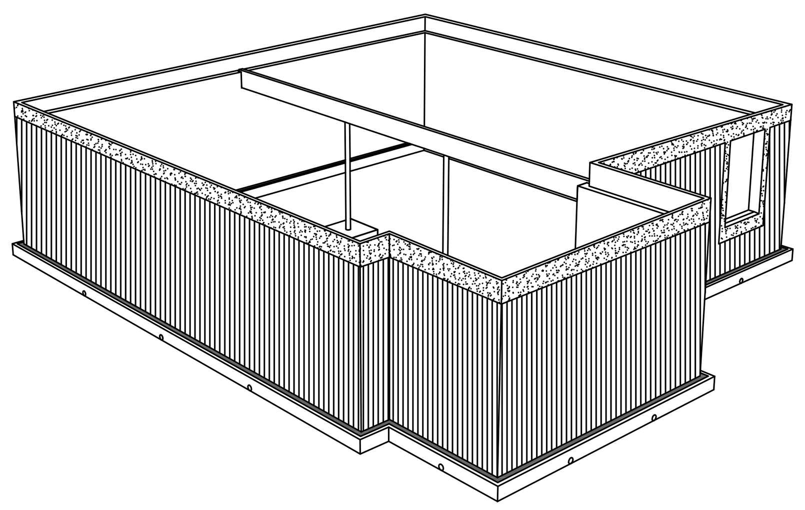
NOTE: FOOTING PENETRATIONS SHOWN AS EXAMPLE ONLY. NOT ALL SHOWN. SEE A-102 FOR PIPE LOCATIONS.

2. APPLY CAPILLARY BREAK ON TOP OF FOOTING.

3. CAST PENETRATIONS, OPENINGS AND BEAM POCKETS INTO CONCRETE FOUNDATION WALL (SEE A-603 FOR PENETRATION SCHEDULE). (NOT SHOWN IN GRAPHIC). SEE A-506 FOR FOUNDATION PENETRATION DETAILS.

4. SEAL FOUNDATION WALL PENETRATIONS TO CONCRETE ON BOTH INTERIOR AND EXTERIOR FACE OF WALL. (NOT SHOWN IN GRAPHIC). SEE A-506 FOR FOUNDATION DETAILS.

5. APPLY DAMPROOFING TO CONCRETE FOUNDATION WALL.



STEP 2

1. INSTALL GEOCOMPOSITE DRAINAGE SYSTEM FROM TOP OF FOOTING TO APPROX. 1'-6" BELOW TOP OF FOUNDATION WALL.

2. INSTALL PERIMETER DRAIN SYSTEM:

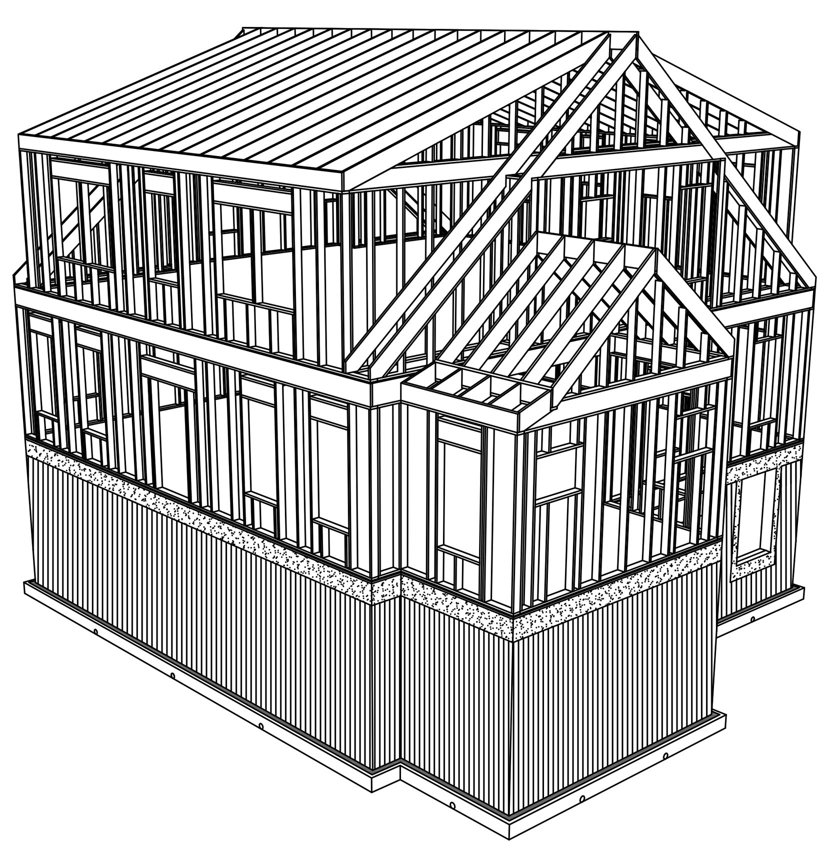
   a. POSITION FILTER FABRIC AT BASE OF FOOTING AROUND PERIMETER OF FOUNDATION. (NOT SHOWN IN GRAPHIC)

   b. INSTALL PERIMETER DRAINAGE SYSTEM. (NOT SHOWN IN GRAPHIC)

   c. PLACE GRAVEL DRAINAGE BED AROUND PERIMETER PIPES. (NOT SHOWN IN GRAPHIC)

   d. WRAP FILTER FABRIC AROUND GRAVEL DRAINAGE BED. (NOT SHOWN IN GRAPHIC)

6. BACKFILL FROM TOP OF FOOTING TO 3'-0" BELOW TOP OF FOUNDATION WALL USING FREE-DRAINING BACKFILL AS SPECIFIED. (NOT SHOWN IN GRAPHIC)



STEP 3

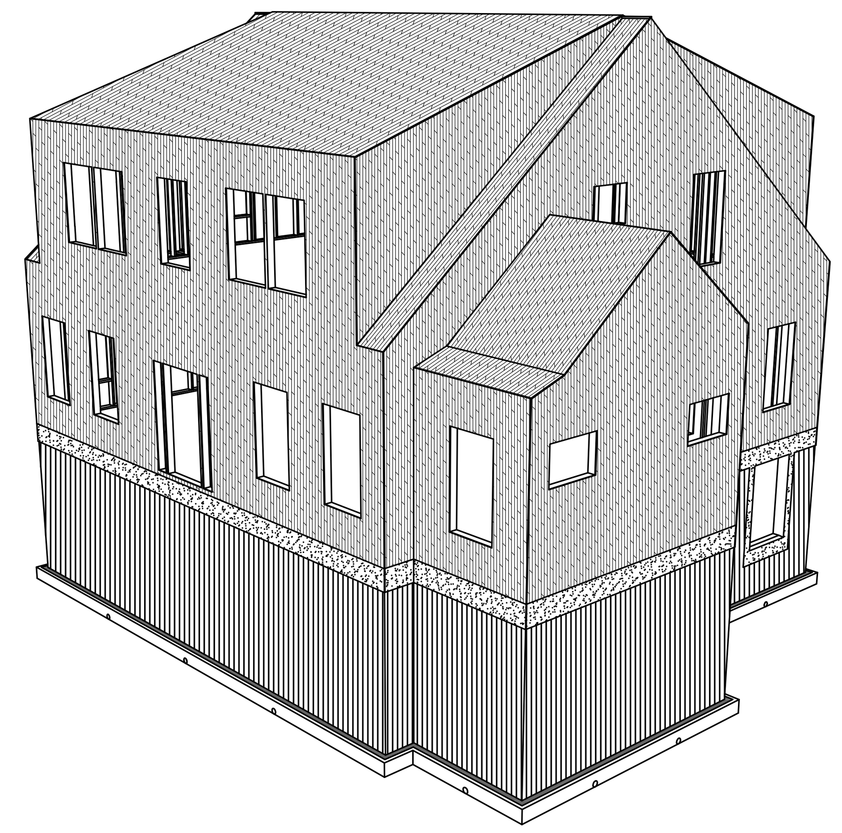
1. FRAME HOUSE ACCORDING TO FRAMING PLANS AND WALL FRAMING ELEVATIONS.

NOTE: FRAMING IN GRAPHIC SHOWN FOR SEQUENCE PURPOSES ONLY, SEE FRAMING PLANS AND WALL FRAMING ELEVATIONS FOR FRAMING LAYOUT.

2. CAST ALL PENETRATIONS (SEE A-603 FOR PENETRATION SCHEDULE) INTO BASEMENT CONCRETE SLAB AND SEAL TO CONCRETE WITH URETHANE SEALANT. (NOT SHOWN IN GRAPHIC). SEE A-506 FOR FOUNDATION DETAILS.

3. SEAL BASEMENT CONCRETE SLAB TO PERIMETER XPS INSULATING SHEATHING WITH URETHANE SEALANT. SEAL TOP OF PERIMETER XPS INSULATING SHEATHING TO CONCRETE FOUNDATION WALL WITH URETHANE SEALANT. (NOT SHOWN IN GRAPHIC)

PROCEED TO
STEP 4 ABOVE

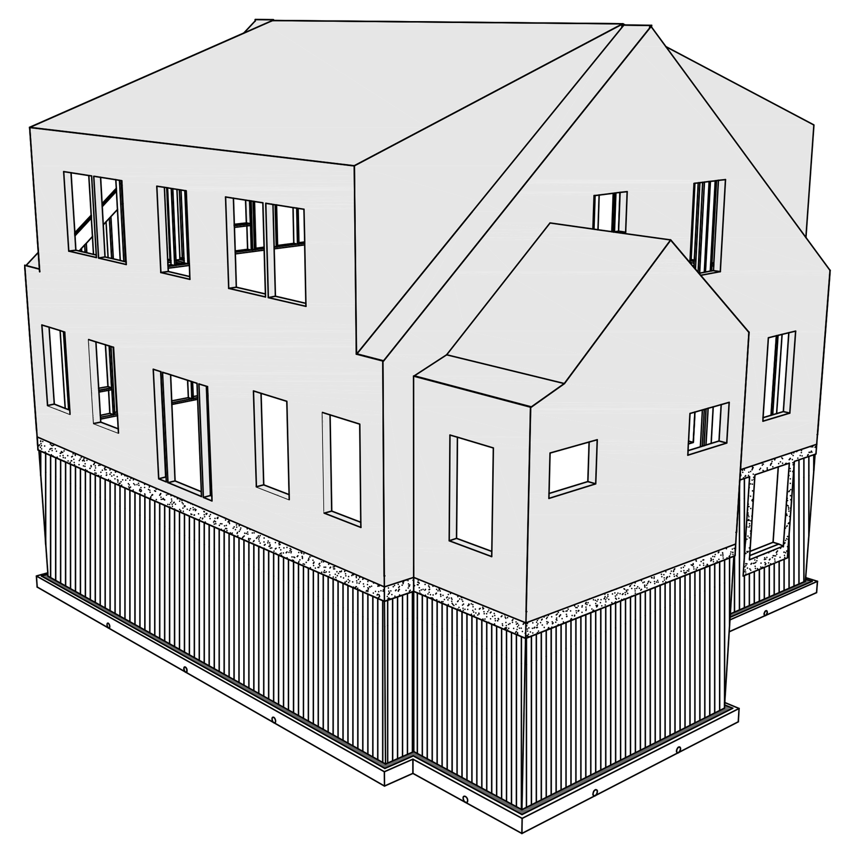


STEP 4

1. INSTALL ½" PLYWOOD SHEATHING ON EXTERIOR WALLS.

2. INSTALL ½" PLYWOOD SHEATHING WITH H-CLIPS ON ROOF.

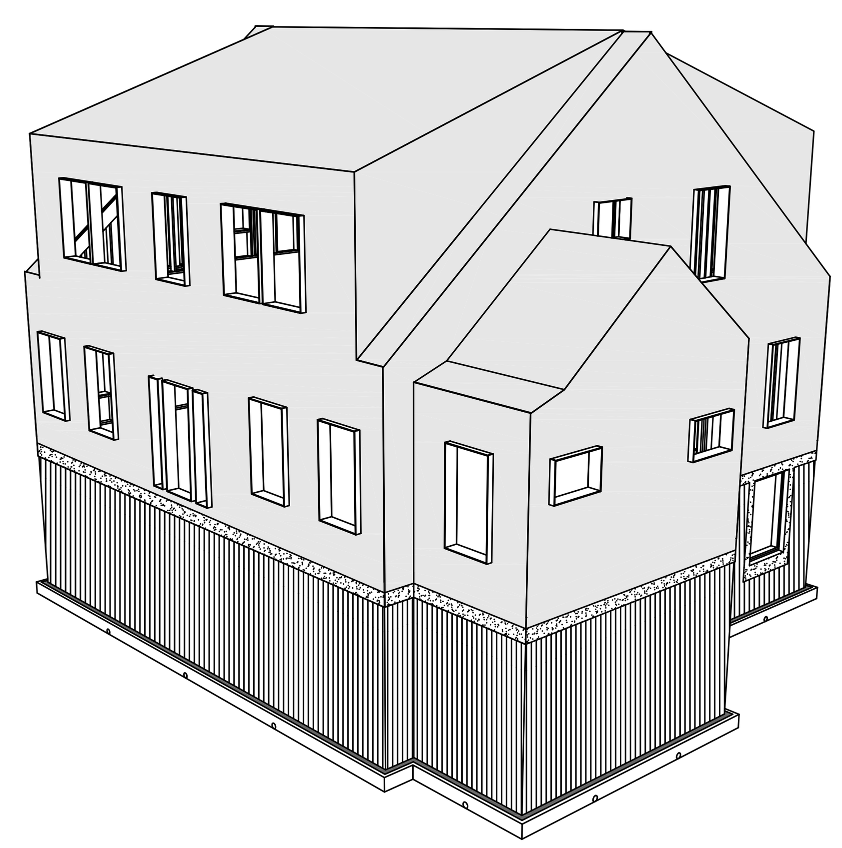
NOTE: DO NOT EXTEND PLYWOOD SHEATHING BEYOND ROOF PLANE AT ROOF-TO -WALL INTERSECTIONS.



STEP 5

1. INSTALL CONTINUOUS FULLY-ADHERED AIR BARRIER MEMBRANE OVER 1/2" PLYWOOD SHEATHING ON WALLS AND ROOF. OVERLAP MEMBRANE ON ROOF OVER MEMBRANE ON WALL TO ENSURE AIRTIGHT CONNECTION. EXTEND MEMBRANE APPROX. 6" PAST BOTTOM OF PLYWOOD SHEATHING ON WALL ONTO CONCRETE FOUNDATION WALL. EXTEND 5 1/2" INTO WINDOW AND DOOR ROUGH OPENINGS.

2. SEAL 4 CORNERS OF WOOD FRAMED ROUGH OPENINGS FOR ALL WINDOWS AND DOORS WITH URETHANE SEALANT.



STEP 6

1. INSTALL PRE-ASSEMBLED ½" PLYWOOD EXTENSION BOX AT ALL WINDOW AND DOOR ROUGH OPENINGS. COAT ALL SURFACES OF PLYWOOD BOX WITH LIQUID-APPLIED VAPOR PERMEABLE WATERPROOFING COATING PRIOR TO BOX CONSTRUCTION AND INSTALLATION. SEAL INTERIOR CORNERS WITH URETHANE SEALANT ONCE INSTALLED. INSTALL BASEMENT WINDOW WOOD BUCKS AND SEAL TO CONCRETE. (SEE WINDOW AND DOOR DETAILS AND INSTALLATION SEQUENCES ON A-503, A-504, AND A-506.)

2. SEAL ALL PLYWOOD BOXES TO AIR BARRIER MEMBRANE ON EXTERIOR OF HOUSE WITH URETHANE SEALANT AT PERIMETER OF PLYWOOD BOX.

3. SEAL ALL PLYWOOD BOXES TO WOOD FRAMING ON INTERIOR OF HOUSE WITH ACRYLIC LATEX SEALANT AT PERIMETER OF PLYWOOD BOX.

4. INSTALL ALL EXTERIOR WALL AND ROOF PENETRATIONS (SEE A-603 FOR PENETRATION SCHEDULE). SEAL PENETRATIONS TO AIR BARRIER MEMBRANE WITH CLOSED CELL FOAM BACKER ROD AND URETHANE SEALANT ON EXTERIOR AND INTERIOR OF HOUSE. SEE A-505 AND A-509 FOR PENETRATION DETAILS.

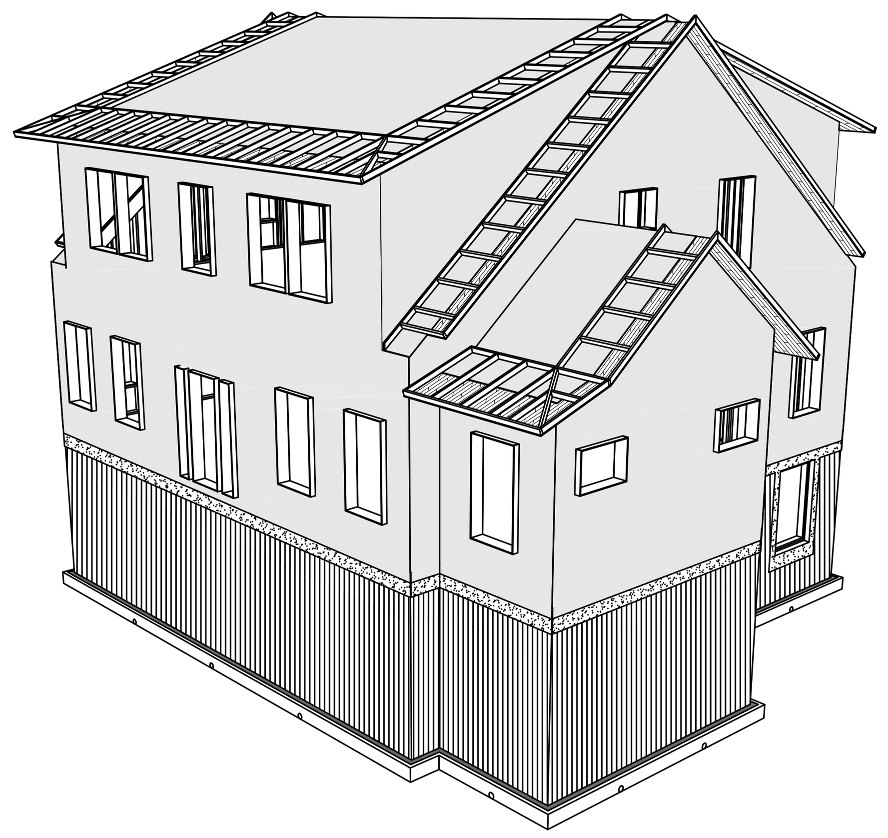
STOP — SEAL PLASTIC SHEET TO INTERIOR SIDE OF PLYWOOD EXTENSION BOX AT ALL WINDOWS AND DOORS, TO INTERIOR SIDE OF ALL FOUNDATION WALL, SLAB, EXTERIOR WALL AND ROOF PENETRATIONS. PERFORM BLOWER DOOR TEST AND AIR SEAL AS REQUIRED TO ACHIEVE AIRTIGHTNESS SPECIFIED IN PERFORMANCE TESTING SECTION OF THE SPECIFICATION.

PROCEED TO
STEP 7 ON A-501B

1 REQUIRED CONSTRUCTION SEQUENCE - PART A

SCALE: N.T.S.

SEE A-501A FOR "SEQUENCE NOTES" AND STEPS 1-6.

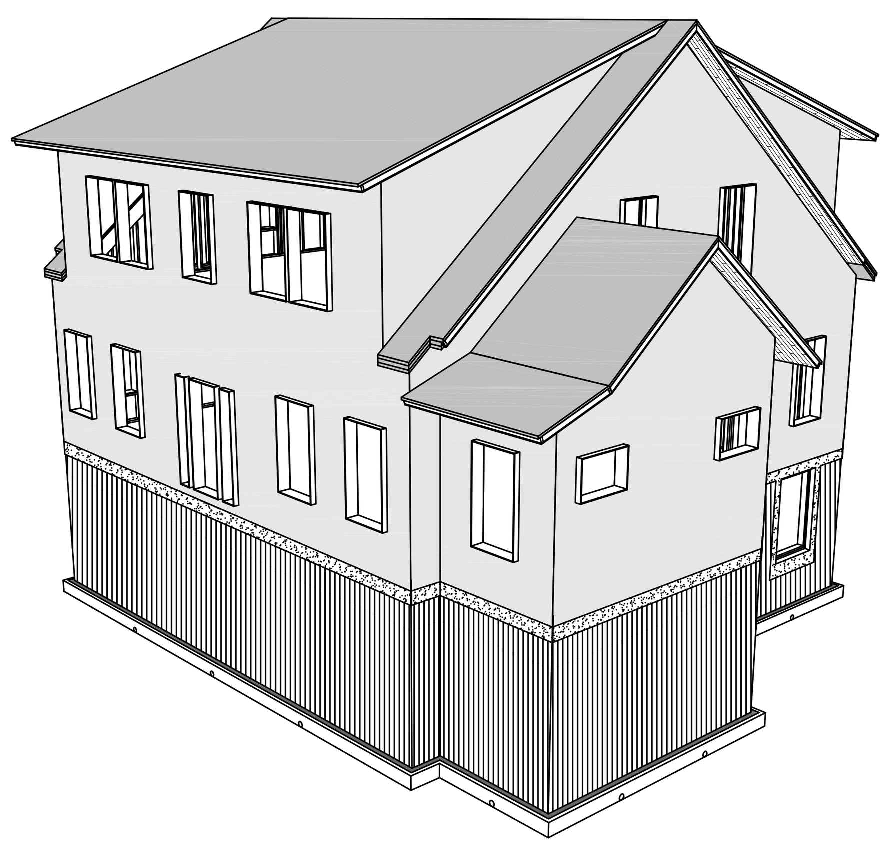


STEP 7

1. INSTALL 2x4 ROOF OVERHANG FRAMING ON TOP OF AIR BARRIER MEMBRANE.

2. INSTALL $\frac{1}{2}$" PLYWOOD SOFFIT UNDER OVERHANG FRAMING.

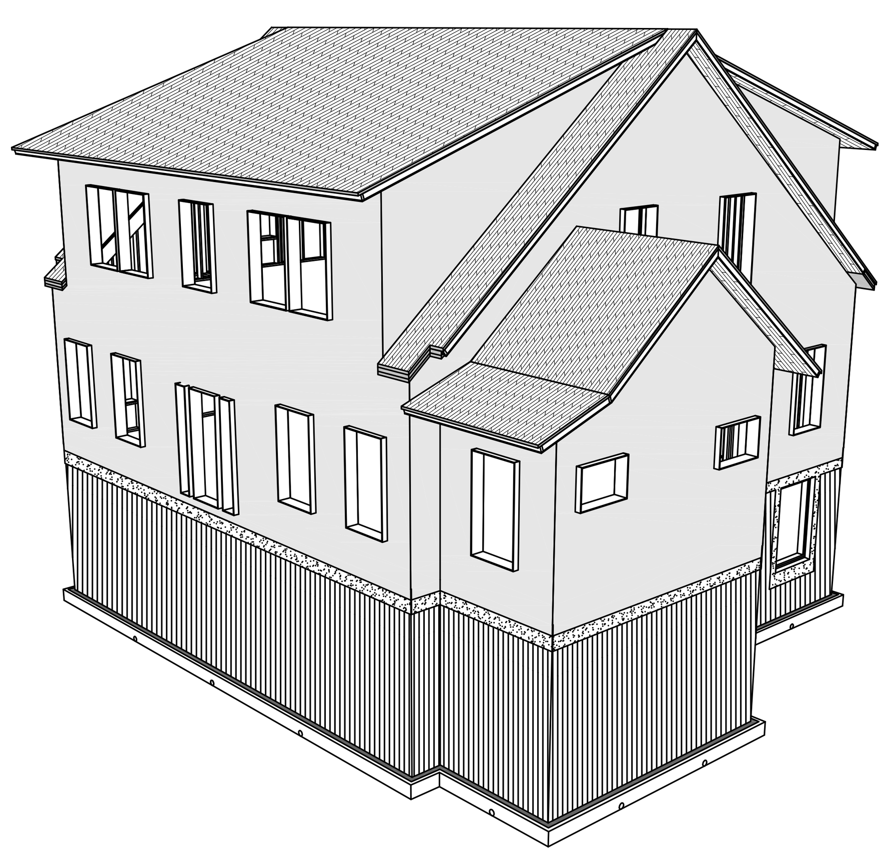
NOTE: FRAMING IN GRAPHIC SHOWN FOR SEQUENCE PURPOSES ONLY, SEE LOWER AND UPPER ROOF FRAMING PLANS FOR FRAMING LAYOUT.



STEP 8

1. INSTALL 5" OF FOIL-FACED POLYISOCYANURATE INSULATING SHEATHING IN 3 LAYERS (1 $\frac{1}{2}$", 2", 1 $\frac{1}{2}$") ON ROOF ONLY. STAGGER JOINTS OF INSULATING SHEATHING.

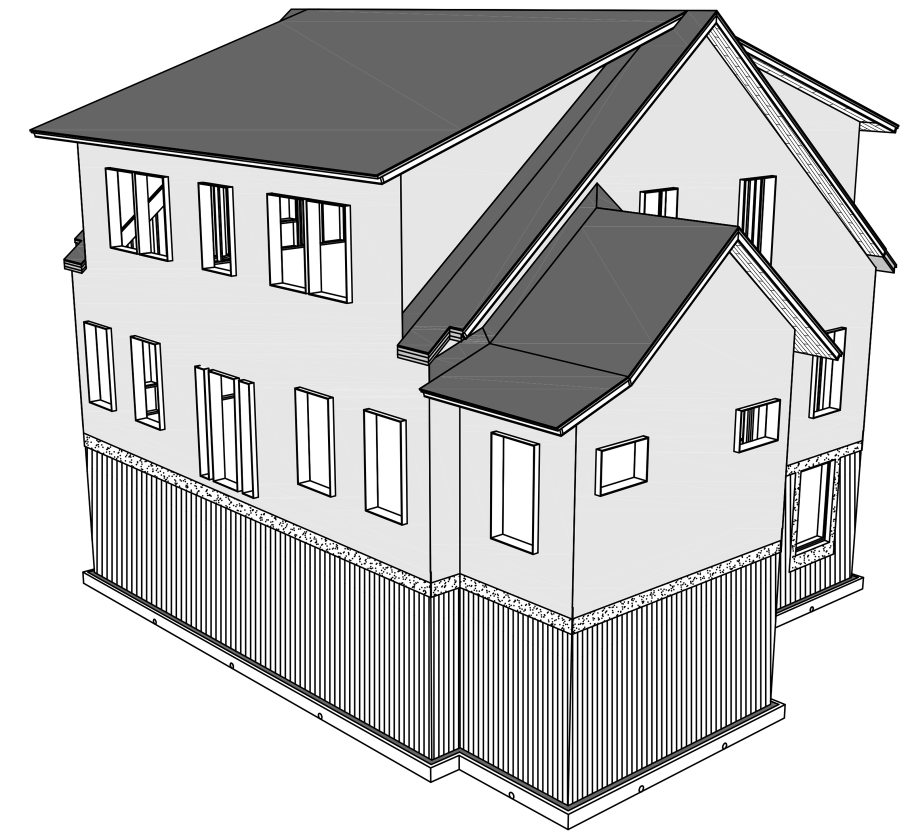
2. SEAL ROOF PENETRATIONS (SEE A-603 FOR PENETRATION SCHEDULE AND A-509 FOR ROOF PENETRATION DETAILS) TO INSULATING SHEATHING WITH CLOSED CELL FOAM BACKER ROD AND URETHANE SEALANT. (NOT SHOWN IN GRAPHIC)



STEP 9

1. INSTALL $\frac{5}{8}$" PLYWOOD SHEATHING WITH H-CLIPS ON ROOF.

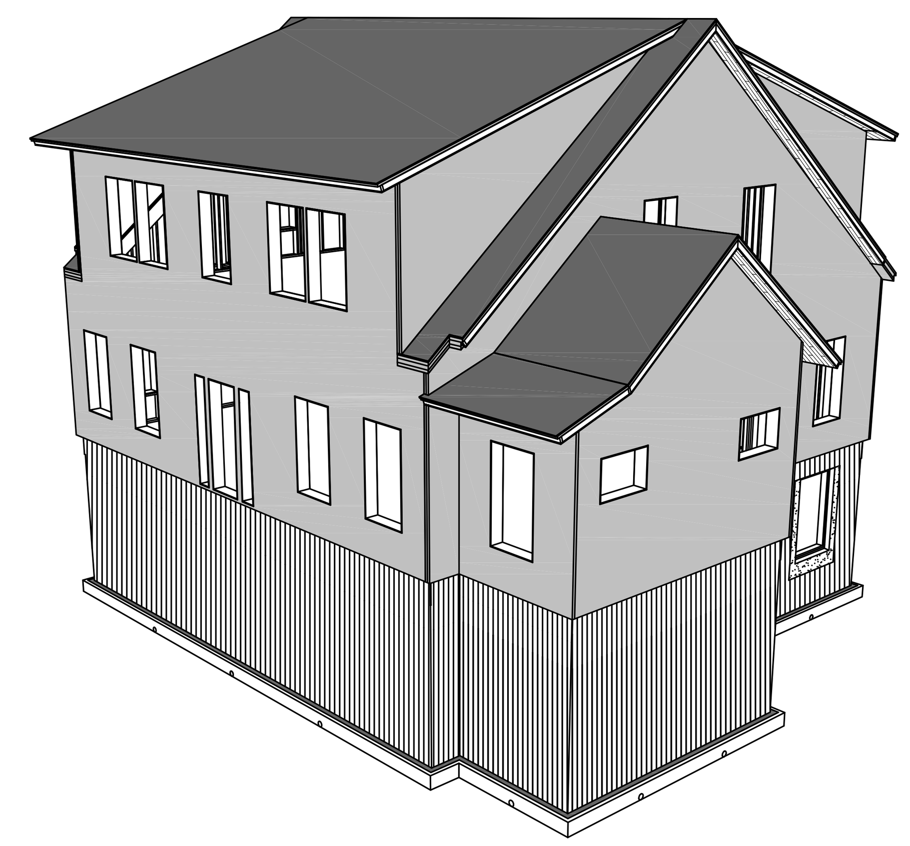
PROCEED TO
STEP 10 ABOVE



STEP 10

1. INSTALL CONTINUOUS FULLY-ADHERED PEEL AND STICK ROOF MEMBRANE (INSTALL MEMBRANE IN 2 STEPS ALONG WITH MEMBRANE FLASHING COLLAR AT ROOF PENETRATIONS - SEE A-509). TURN MEMBRANE UP WALL 12" MIN. AT ROOF TO WALL INTERSECTIONS. TAPE TOP EDGE OF MEMBRANE TO AIR BARRIER MEMBRANE ON WALL.

2. INSTALL MEMBRANE FLASHING COLLAR AT ROOF PENETRATIONS. SEE A-603 FOR PENETRATION SCHEDULE AND A-509 FOR ROOF PENETRATION DETAILS.

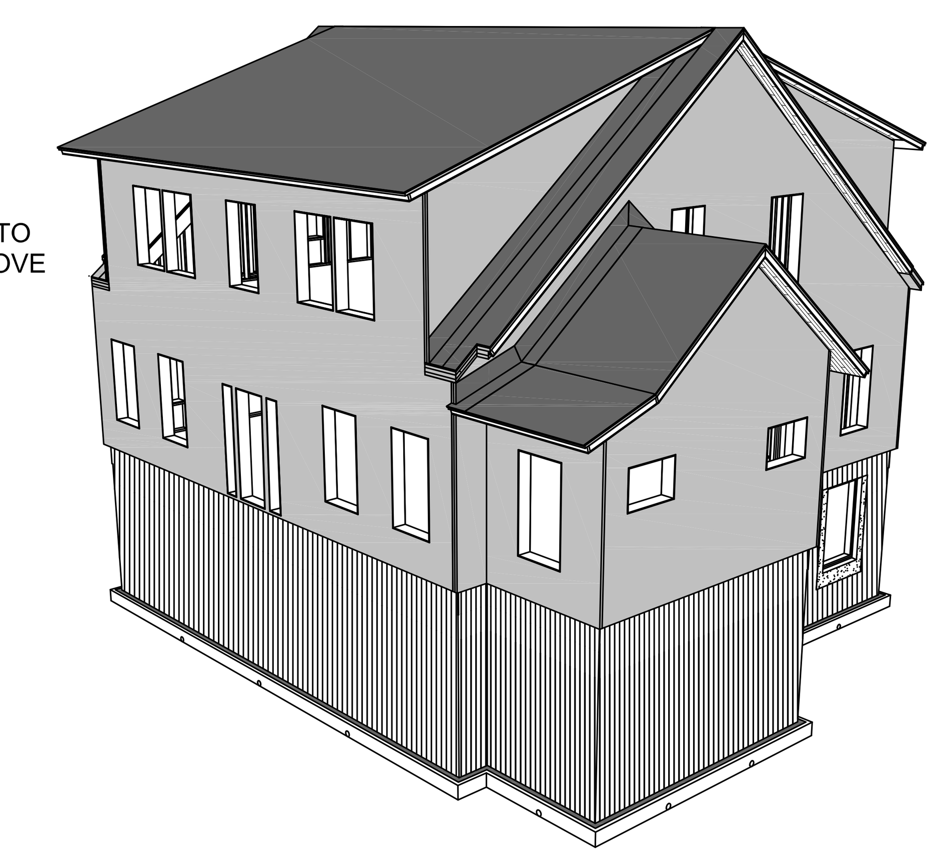


STEP 11

1. INSTALL (2) LAYERS OF 2" FOIL-FACED POLYISOCYANURATE INSULATING SHEATHING ON EXTERIOR WALLS. INSTALL INSULATING SHEATHING WITH TEMPORARY FASTENERS (NOT FURRING STRIPS AT THIS STEP) TO ALLOW FOR COMPLETE TAPING OF INSULATING SHEATHING JOINTS. FURRING STRIPS TO BE INSTALLED AFTER WINDOWS AND DOORS HAVE BEEN INSTALLED. STAGGER AND TAPE JOINTS OF INSULATING SHEATHING. OUTER LAYER OF INSULATING SHEATHING IS THE DRAINAGE PLANE. NOTE: FOUNDATION FLASHING (ALUMINUM COIL STOCK) MUST BE ATTACHED BEFORE INSULATING SHEATHING IS INSTALLED AT THE BASE OF THE EXTERIOR WALL (NOT SHOWN IN GRAPHIC).

2. SEAL WALL PENETRATIONS (SEE A-603 FOR PENETRATION SCHEDULE) TO INSULATING SHEATHING WITH CLOSED CELL FOAM BACKER ROD AND URETHANE SEALANT. (NOT SHOWN IN GRAPHIC). SEE A-505 FOR WALL PENETRATION SEALING DETAILS.

3. COMPLETE THE INSTALLATION OF THE GEOCOMPOSITE DRAINAGE SYSTEM, OVERLAPPING FIRST LAYER OF SYSTEM 6" MIN. AND EXTENDING UP TO THE BOTTOM OF INSULATING SHEATHING (BUT UNDER FOUNDATION FLASHING). SEE 3/A-401 FOR TOP OF FOUNDATION DETAIL.



STEP 12

1. INSTALL A STRIP OF PEEL-AND-STICK ROOF MEMBRANE AT ROOF-TO-WALL INTERSECTIONS. TURN MEMBRANE UP WALL 12" MIN. AND EXTEND 12" MIN. ACROSS ROOF. TAPE TOP EDGE OF MEMBRANE TO INSULATING SHEATHING ON WALL.

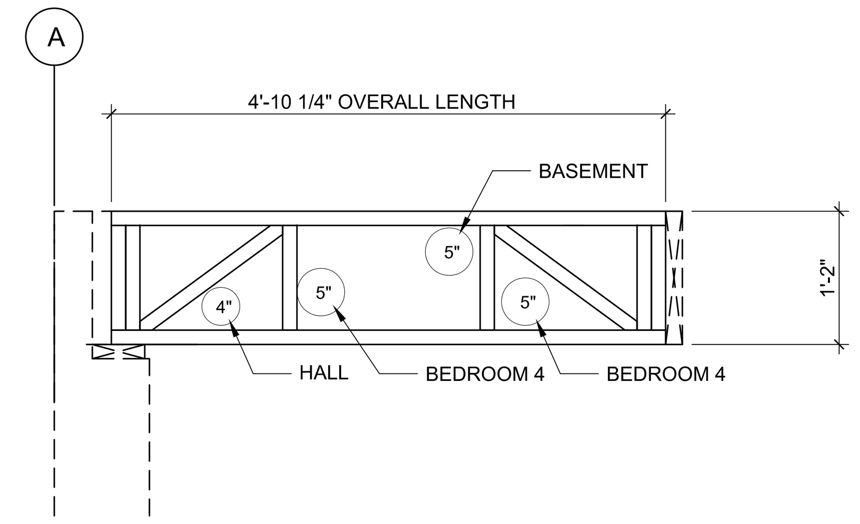
PROCEED TO
STEP 13 ON A-501C

1 REQUIRED CONSTRUCTION SEQUENCE - PART B

SCALE: N.T.S.

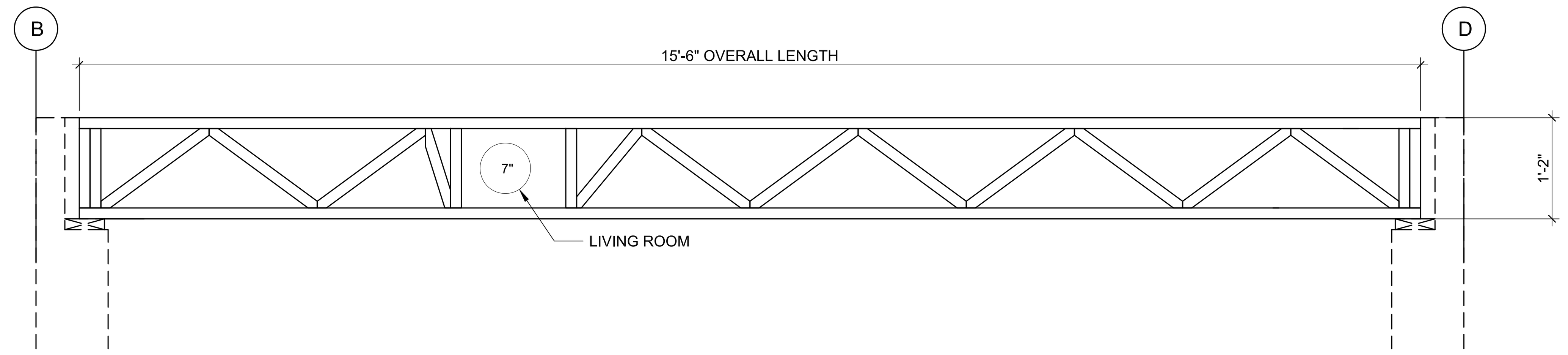
GENERAL SHEET NOTES

1. TRUSS ELEVATIONS SHOWN SAME AS SUBMITTED CONSTRUCTION SHOP DRAWINGS.
2. DUCTWORK SHOWN AS OVERLAPPING IN TRUSS ELEVATION EXISTS IN SEPARATE TRUSSES, NO OVERLAPPING DUCTWORK WITHIN ONE TRUSS EXISTS, SEE AR-D-801 AND AR-D-802 COORDINATION PLANS.



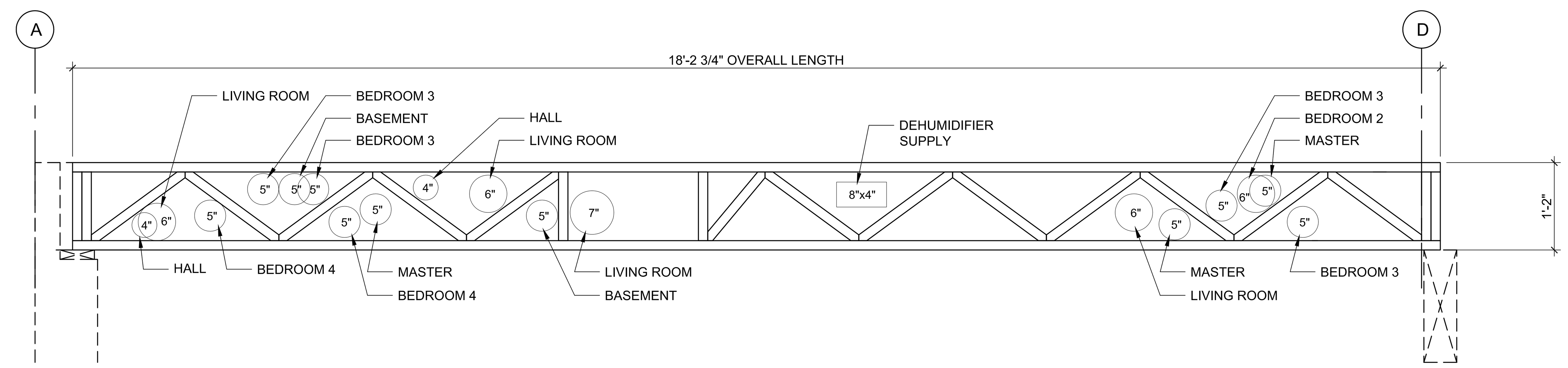
4 14" DEEP OPEN WEB FLOOR TRUSS - TYPE "D" (F02) ELEVATION

SCALE: 3/4" = 1'-0"



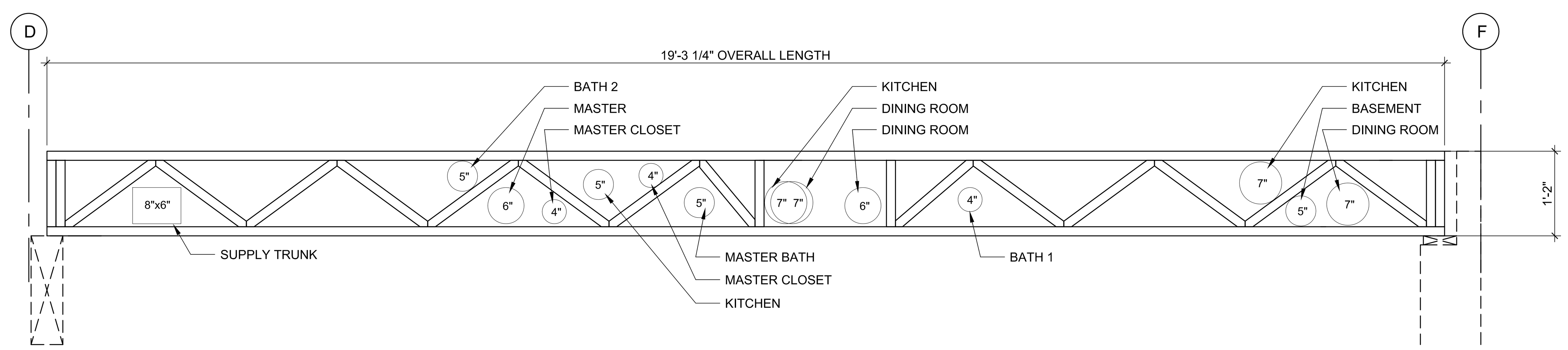
3 14" DEEP OPEN WEB FLOOR TRUSS - TYPE "C" (F03) ELEVATION

SCALE: 3/4" = 1'-0"



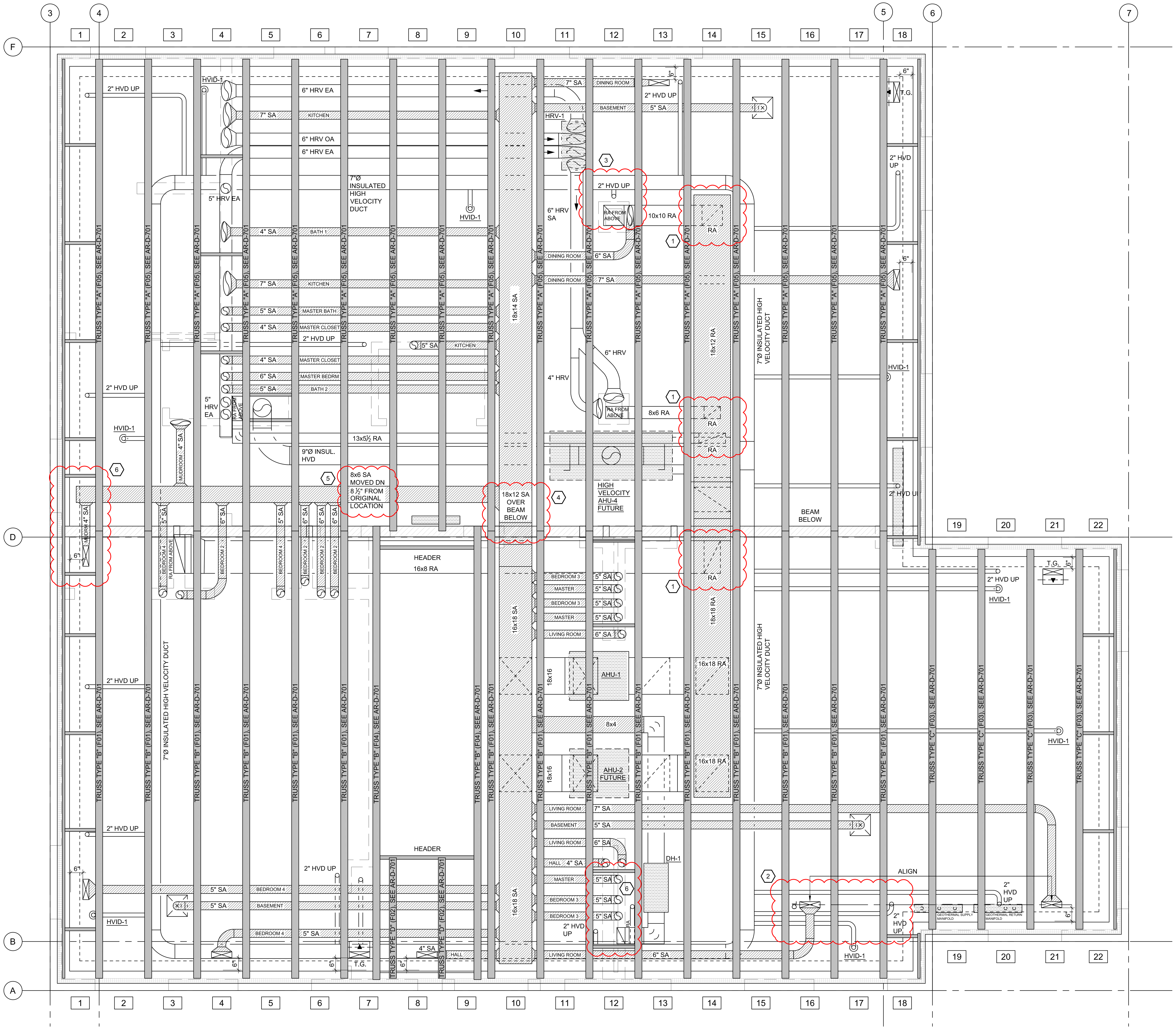
2 14" DEEP OPEN WEB FLOOR TRUSS - TYPE "B" (F01, F04 SIM) ELEVATION

SCALE: 3/4" = 1'-0"



1 14" DEEP OPEN WEB FLOOR TRUSS - TYPE "A" (F05) ELEVATION

SCALE: 3/4" = 1'-0"



FIRST FLOOR FRAMING & HVAC COORDINATION PLAN

SCALE: 1/2" = 1'-0"

GENERAL SHEET NOTES

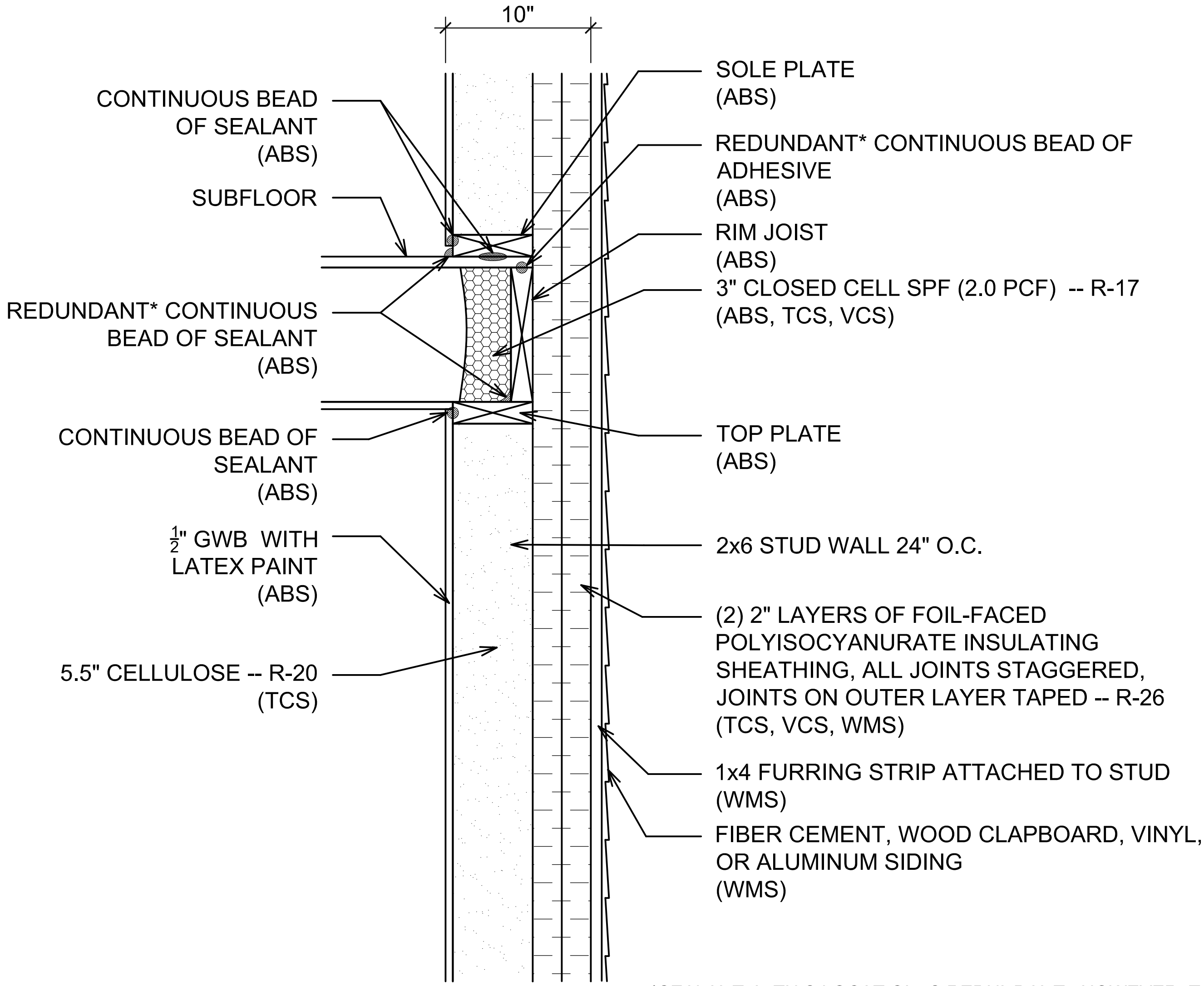
1. COORDINATION PLAN COMBINES FRAMING PLAN AND MECHANICAL PLAN TO LOCATE DUCTWORK WITHIN SPECIFIC FLOOR TRUSS BAYS.
2. FLOOR TRUSS BAYS LABELED FOR COORDINATION.
3. CLOUD INDICATES DUCTWORK OR FRAMING REVISION OR CLARIFICATION.
4. T.G. = TRANSFER GRILLE
5. HATCH INDICATES DUCTWORK TO BE LOCATED BETWEEN TRUSSES AND ALONG TRUSSES WITHIN FLOOR TRUSS OPENINGS. SEE AR-D-701 AND AR-D-702 FOR FLOOR TRUSS ELEVATIONS CALLING OUT DUCTWORK.
6. INSULATED MAIN SUPPLY TRUNK TO BE TIGHT TO UNDERSIDE OF SUBFLOOR.
7. TRUSS TYPES IN CONSTRUCTION SUBMITTALS INDICATED IN "()".
8. HIGH VELOCITY DUCT SYSTEM TO BE LOCATED BELOW FLOOR TRUSSES.
9. DUCTWORK DAMPERS NOT SHOWN FOR DRAWING CLARITY.
10. TRANSFER GRILLES AND FLOOR SUPPLY REGISTERS TO BE 6" FROM EDGE OF FOUNDATION WALL AS INDICATED ON DRAWING.

SHEET KEYNOTES

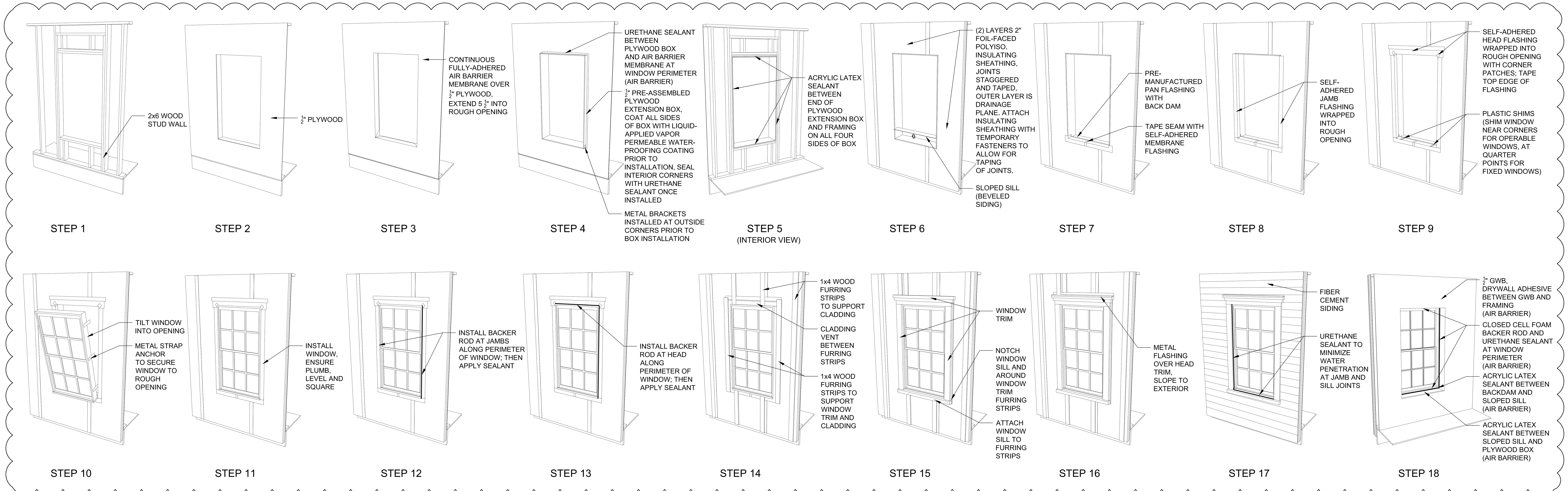
1. RETURN DUCTWORK TO CONNECT TO RETURN TRUNK AT UNDERSIDE OF RETURN TRUNK.
2. LIVING ROOM SUPPLY AND HVD TO BE RELOCATED TO BE IN FRONT OF BUILT-IN BENCH, NOT RUNNING UP THROUGH BENCH.
3. HVD TO BE RELOCATED TO AVOID TRUSS.
4. INSULATED SUPPLY TRUNK TO REDUCE IN HEIGHT 2" OVER BEAM.
5. SUPPLY TRUNK TO MOVE DOWN TO FIT WITHIN TRUSS ELEVATIONS SHOWN ON CONSTRUCTION SUBMITTALS.
6. BLOCKING TO BE RELOCATED BASED ON DUCTWORK AND TRUSS COORDINATION.

Framing:	2x6 STRUCTURAL STUD
Exterior Cladding:	VENTED LAP SIDING
Location of Insulation:	WALL CAVITY + EXTERIOR
Location of Drainage Plane:	INSULATING SHEATHING
Location of Air Barrier:	AIRTIGHT DRYWALL APPROACH
Insulation Type, R-Value:	5.5" CELLULOSE + 4" FOIL-FACED POLYISOCYANURATE, R-46
Climate/Zone:	COLD / ZONES 5, 6, 7, AND 8

ABS: *Air Barrier System component*
TCS: *Thermal Control System component*
VCS: *Vapor Control System component*
WMS: *Water Management System component*



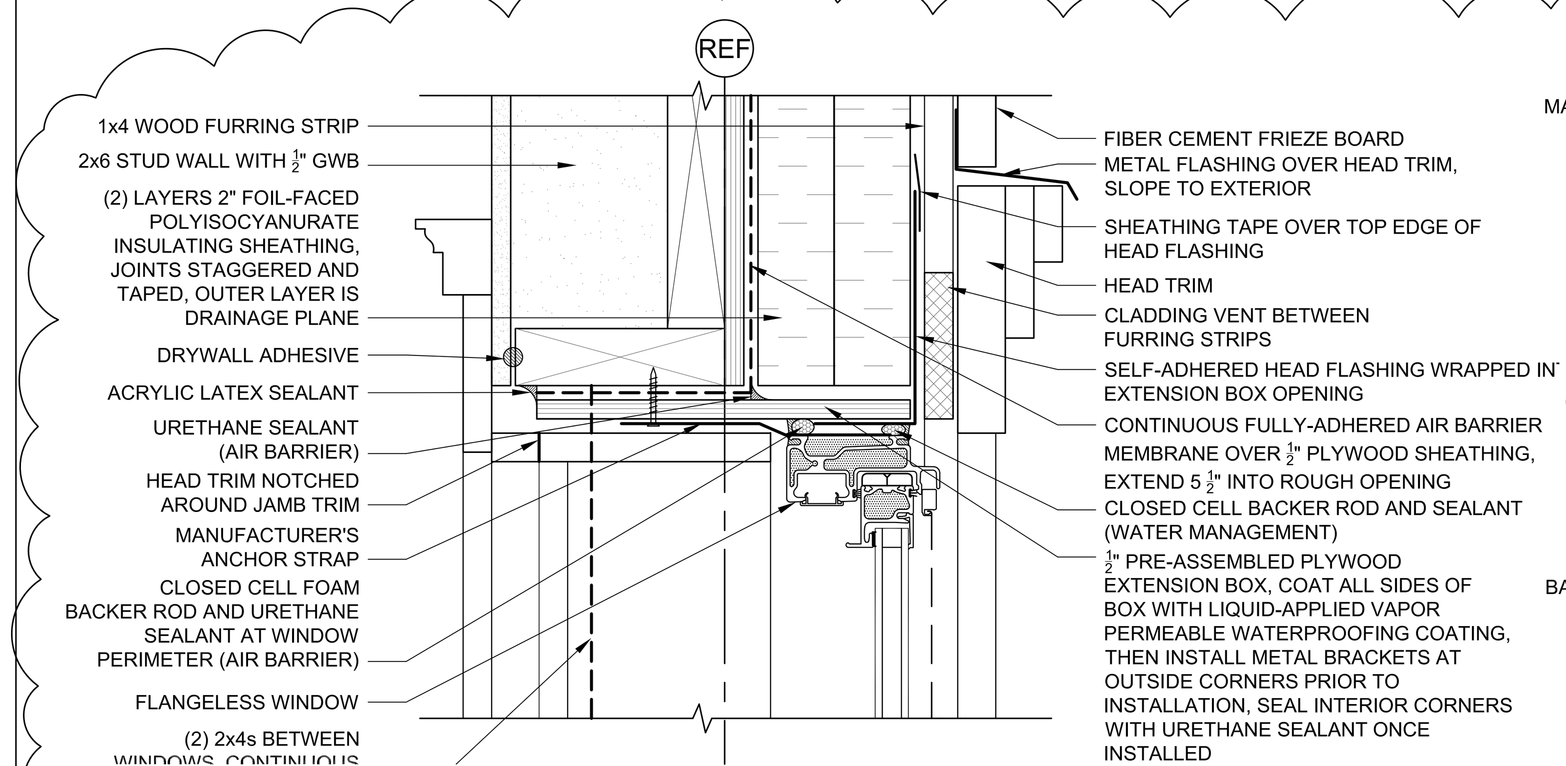
*SEALANT IN THIS LOCATION IS REDUNDANT. HOWEVER IT IS RECOMMENDED PRACTICE TO INCLUDE THIS REDUNDANCY TO COMPENSATE FOR ANY DISCONTINUITIES THAT MAY BE INTRODUCED BY DIFFICULT SITE CONDITIONS OR IMPERFECT WORKMANSHIP.



7 WINDOW INSTALLATION SEQUENCE

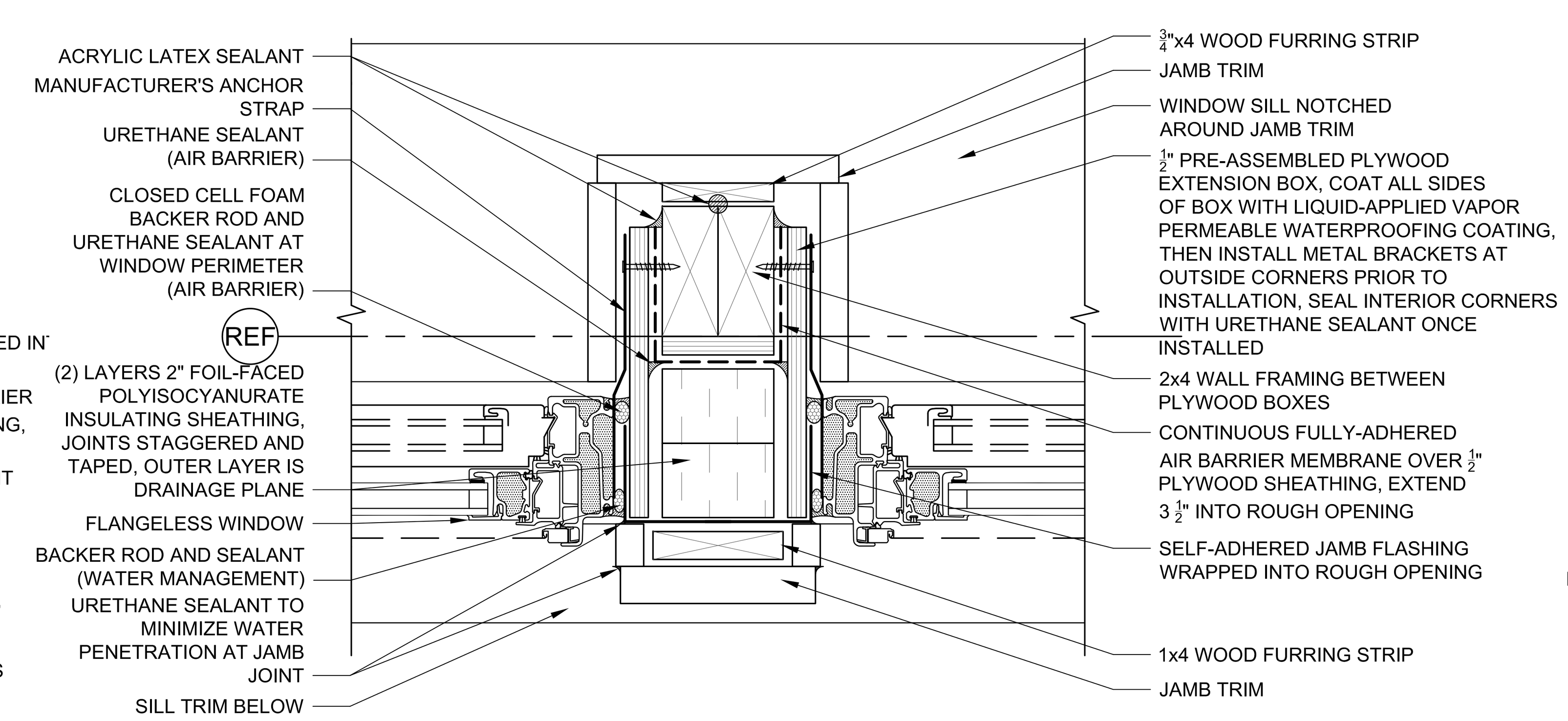
SCALE: N.T.S.

2



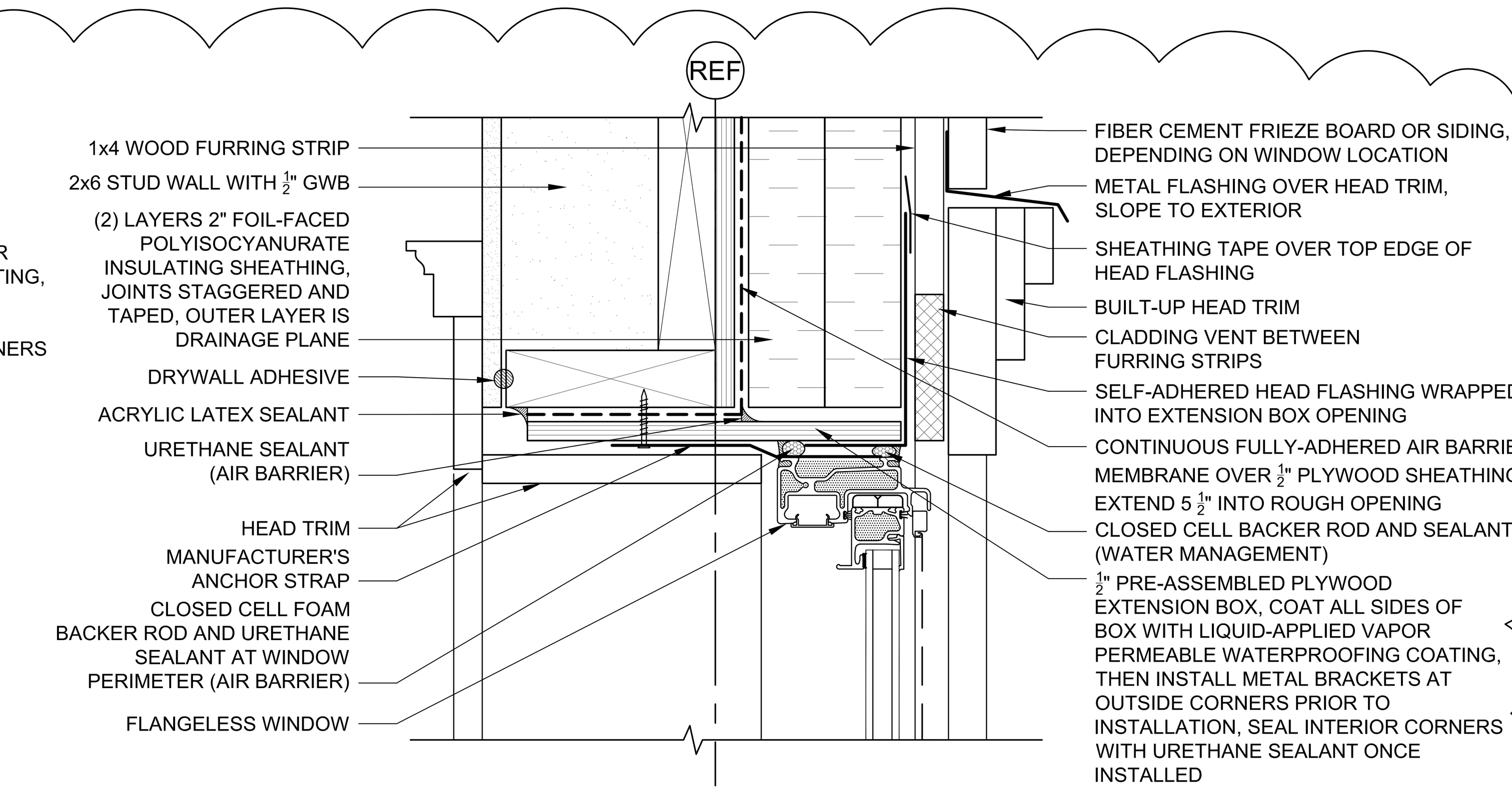
6 GANGED WINDOW HEAD DETAIL

SCALE: 3" = 1'-0"



4 GANGED WINDOW JAMB DETAIL

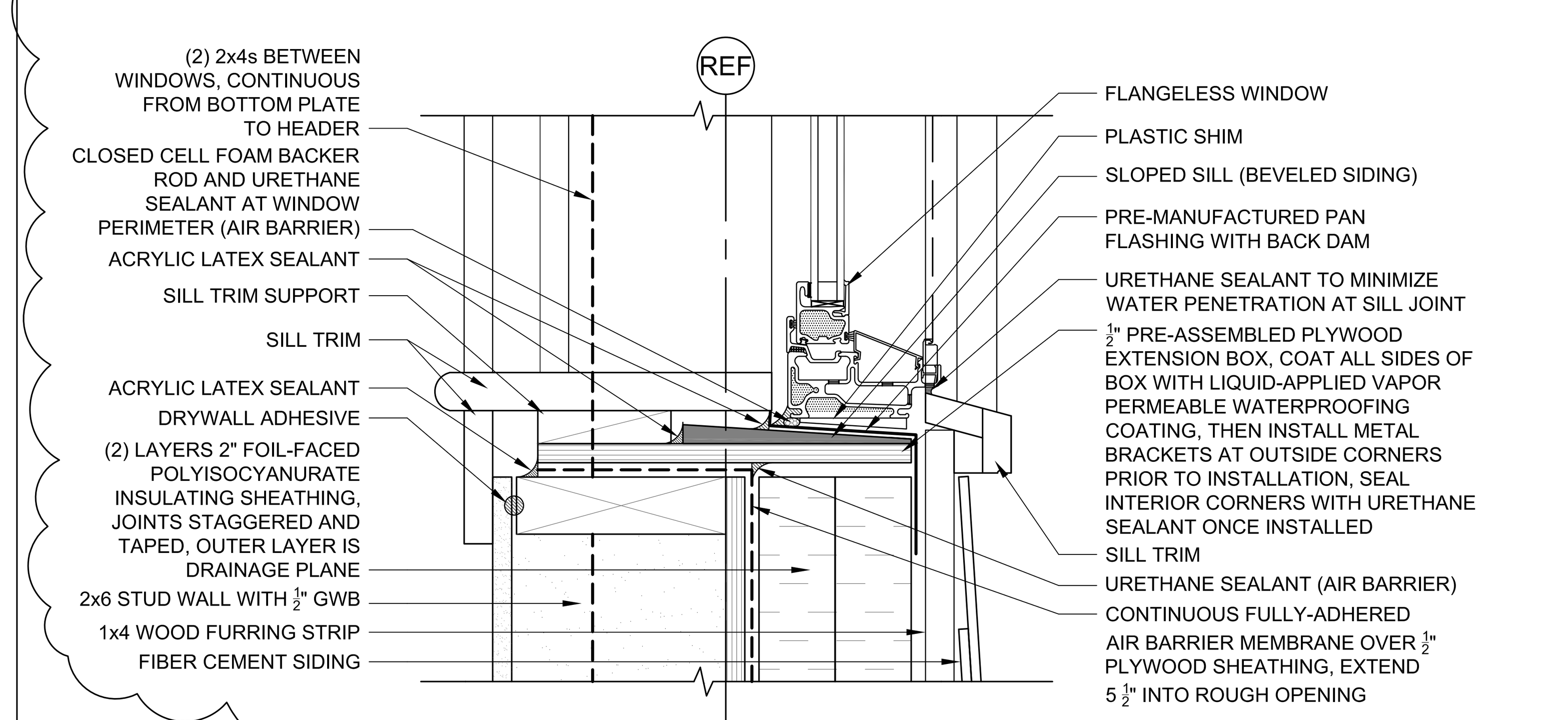
SCALE: 3" = 1'-0"



2 WINDOW HEAD DETAIL

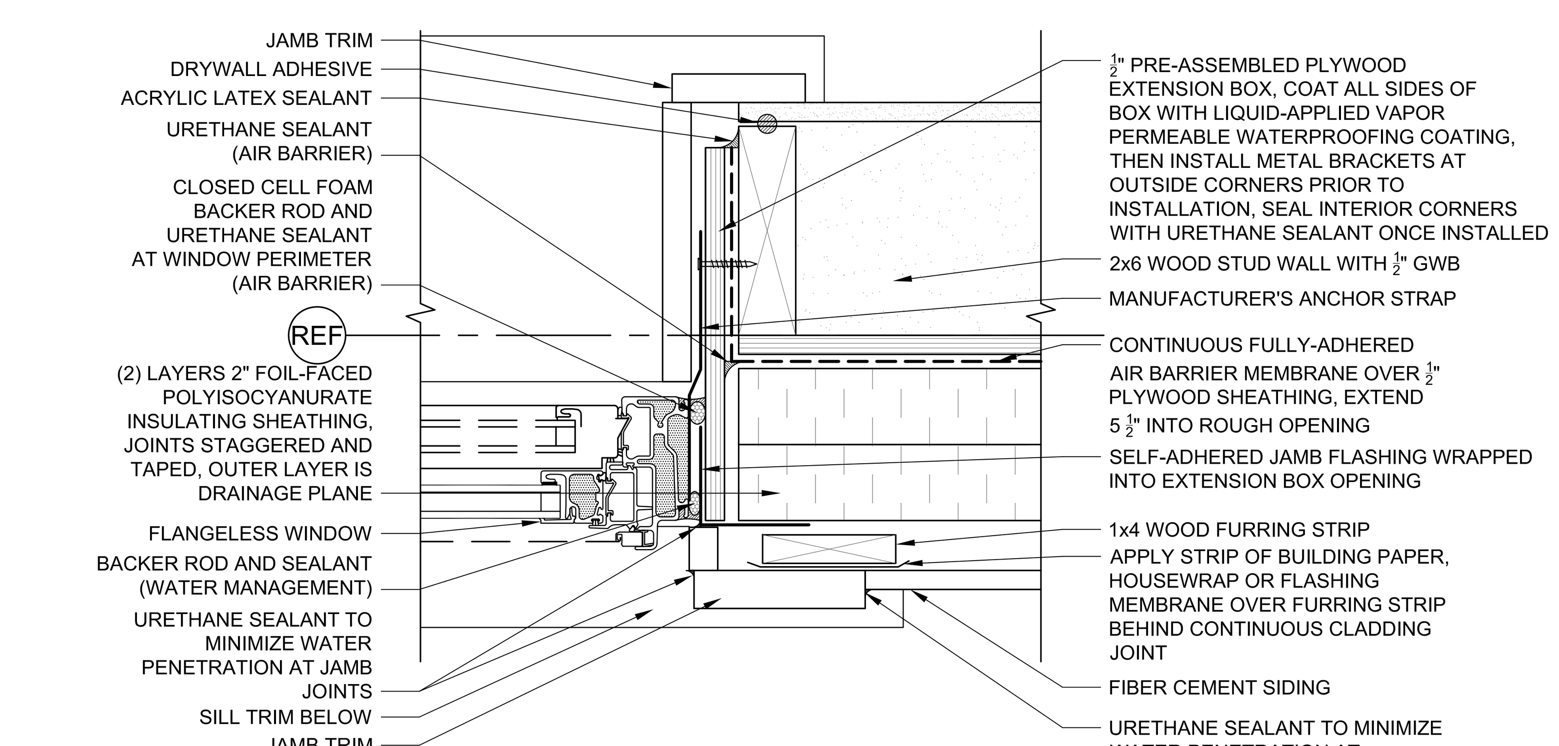
SCALE: 3" = 1'-0"

2 03/07/11 BSC-ASI-006



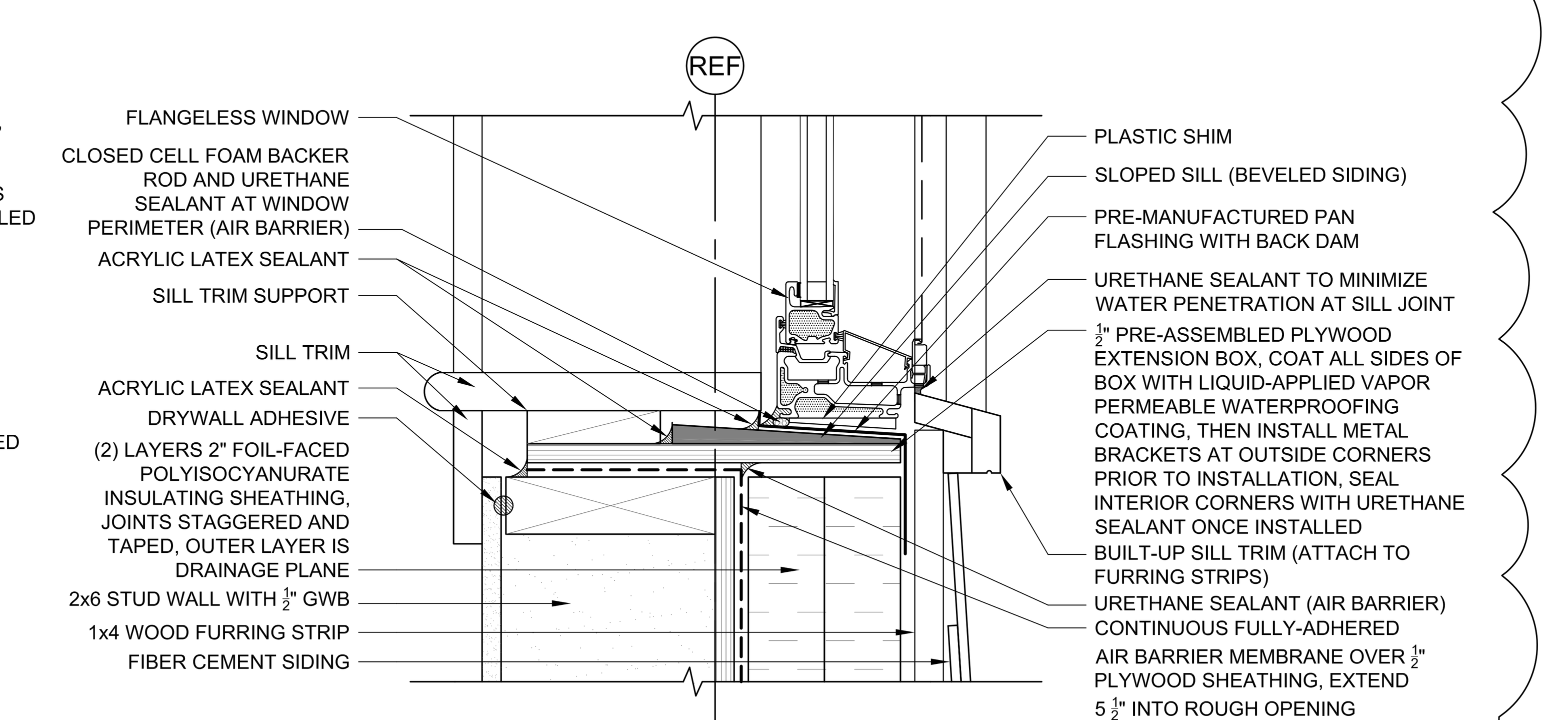
5 GANGED WINDOW SILL DETAIL

SCALE: 3" = 1'-0"



3 WINDOW JAMB DETAIL

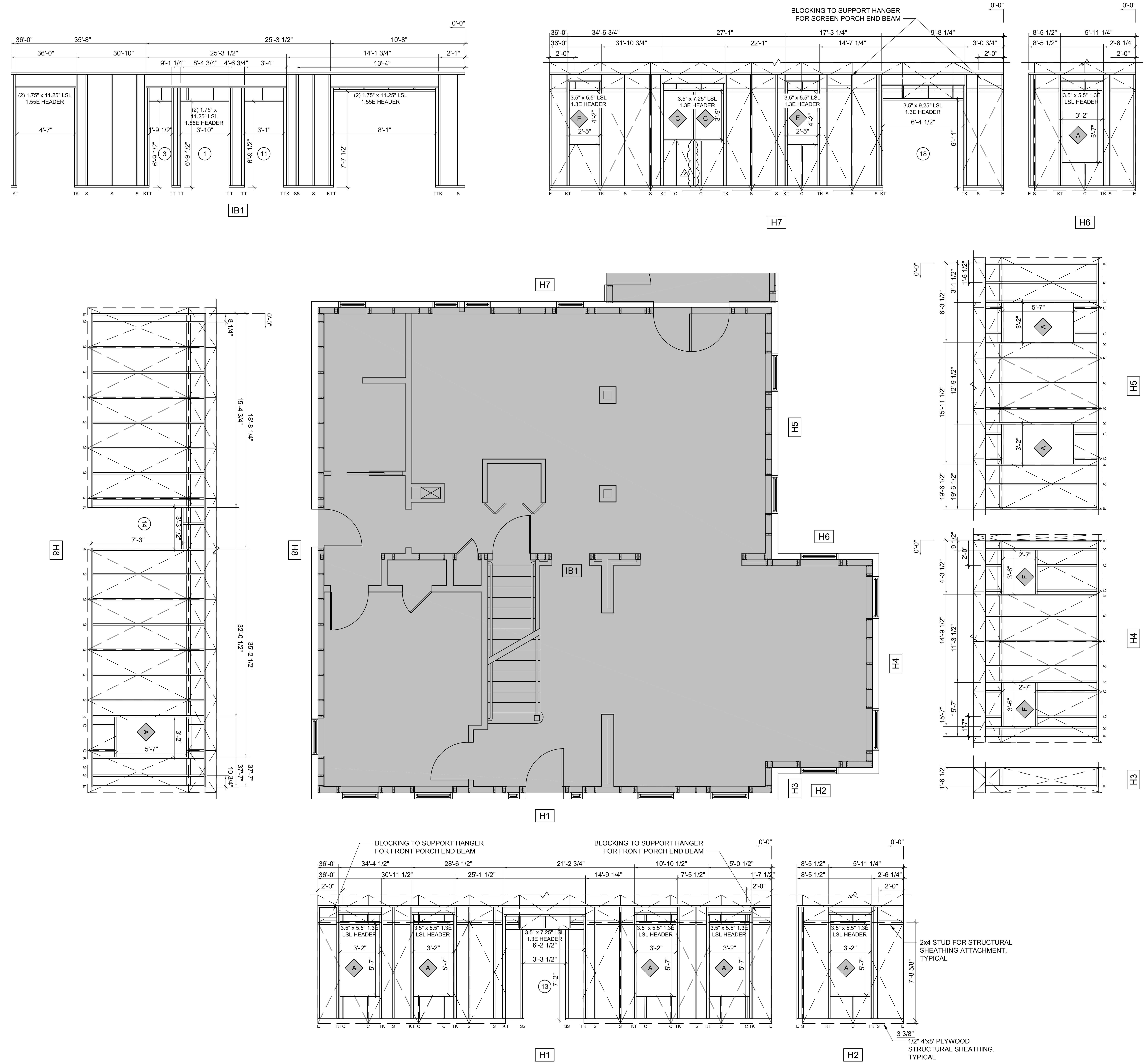
SCALE: 3" = 1'-0"



1 WINDOW SILL DETAIL

SCALE: 3" = 1'-0"

2



1 FIRST FLOOR KEY PLAN & WALL FRAMING ELEVATIONS

SCALE: 1/4" = 1'-0"

GENERAL SHEET NOTES

1. REAR WALL FRAMING ELEVATIONS DRAWN AS SEEN FROM INTERIOR; INTERIOR BEARING WALL FRAMING ELEVATION DRAWN AS SEEN FROM THE FRONT; ALL OTHER ELEVATIONS DRAWN AS SEEN FROM EXTERIOR
2. TYPICAL WALL HEIGHT = 9'-1".
3. TYPICAL FIRST FLOOR WINDOW FRAMING HEAD HEIGHT = 7'-6 3/4".
4. WINDOW AND EXTERIOR DOOR FRAMING OPENING DIMENSIONS TO BE ADJUSTED PER MANUFACTURER SELECTION AS FOLLOWS:
   A. FRAMING WIDTH FOR DOORS AND WINDOWS: INCREASE THE MANUFACTURER'S SPECIFIED ROUGH OPENING WIDTH BY ADDING ½" TO EACH SIDE.
   B. FRAMING HEIGHT FOR WINDOWS: INCREASE THE MANUFACTURER'S SPECIFIED ROUGH OPENING HEIGHT BY ADDING ½" TO THE TOP AND 1" TO THE BOTTOM.
   C: FRAMING HEIGHT FOR DOORS: INCREASE THE MANUFACTURER'S SPECIFIED ROUGH OPENING HEIGHT BY ADDING 1/2" TO THE TOP.
5. FRAMING STUDS TO BE FSC-CERTIFIED LUMBER.
6. LIMIT THE OVERALL ESTIMATED WASTE FACTOR ON THE FRAMING ORDER TO 10% OR LESS.'
7. STRUCTURAL SHEATHING CONNECTIONS (TO RESIST ROOF UPLIFT):

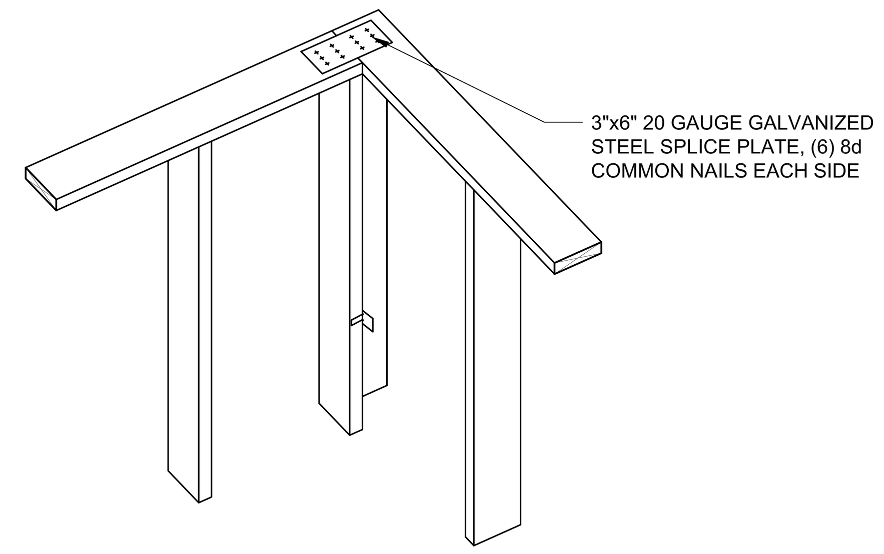
   LAP SHEATHING ON RAFTER RIM BOARD: MINIMUM 8d NAILS AT 3" O.C.

   HORIZONTAL SHEATHING EDGES AT BLOCKING OR FRAMING: MINIMUM 8d NAILS AT 3" O.C.

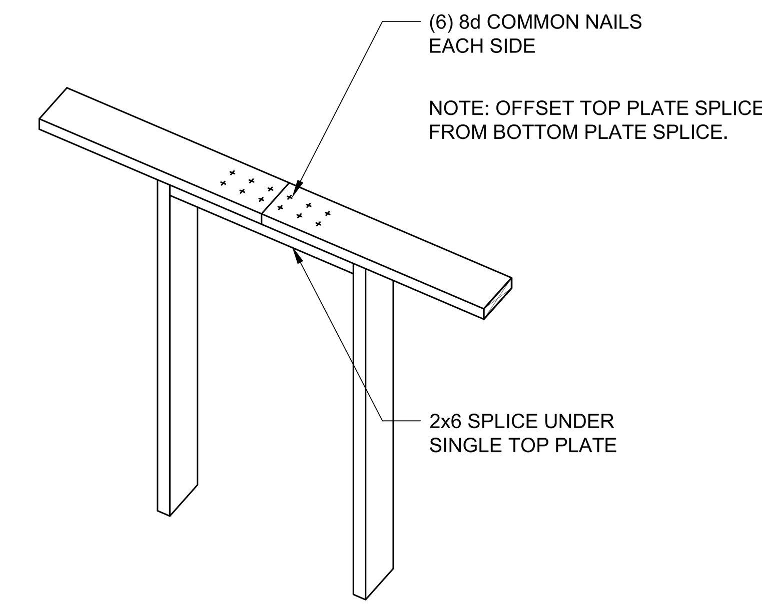
   HORIZONTAL SHEATHING EDGES BELOW SECOND FLOOR: MINIMUM 8d NAILS AT 6" O.C.
8. DESIGNATORS USED FOR VERTICAL MEMBERS OF THE WALL FRAMING ELEVATIONS ARE AS FOLLOWS: KT - KING TRIMMER, T - TRIMMER, S - STUD, C - CRIPPLE, E - END STUD.
9. DESIGNATORS USED IN THE ROUGH OPENINGS OF WALL FRAMING ELEVATIONS REFER TO THE WINDOW AND DOOR TYPES. 1

SHEET KEYNOTES

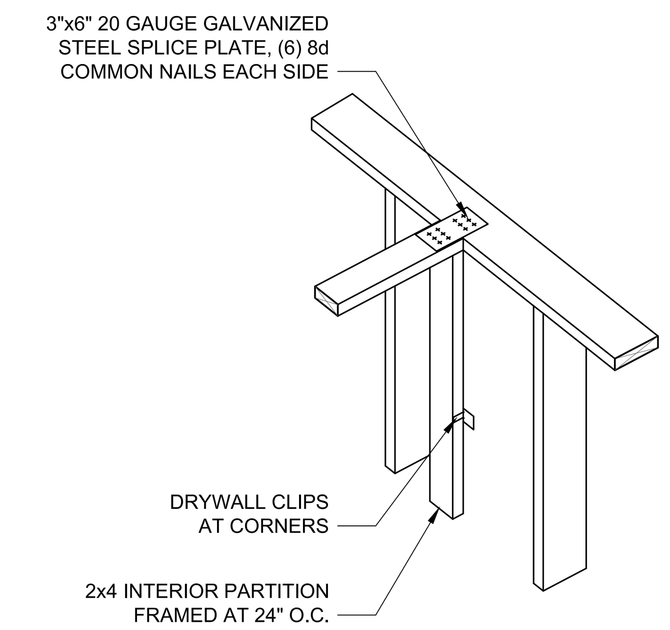
2	03/07/11	BSC-ASI-006
1	02/28/11	BSC-ASI-005



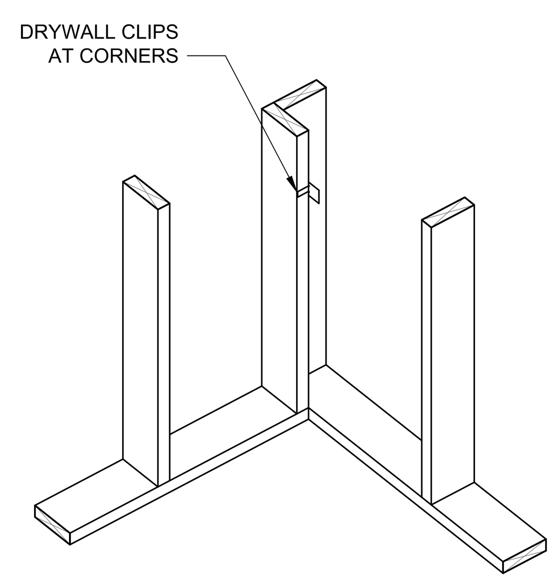
9 TWO-STUD CORNER - TOP
SCALE: N.T.S.



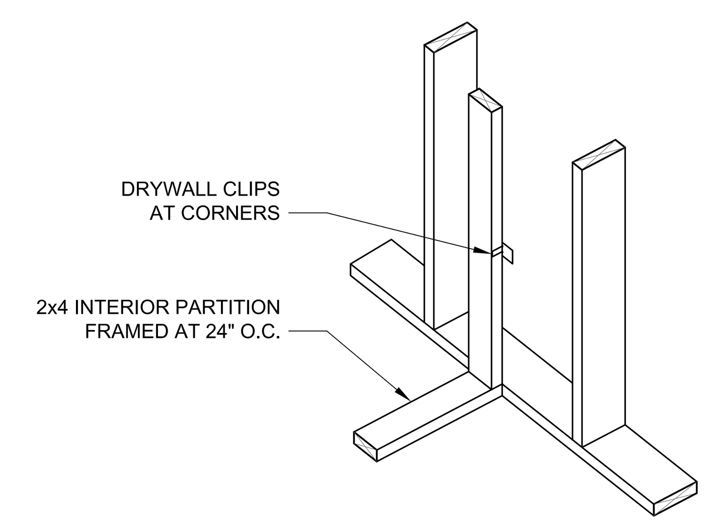
6 SINGLE TOP PLATE SPLICE
SCALE: N.T.S.



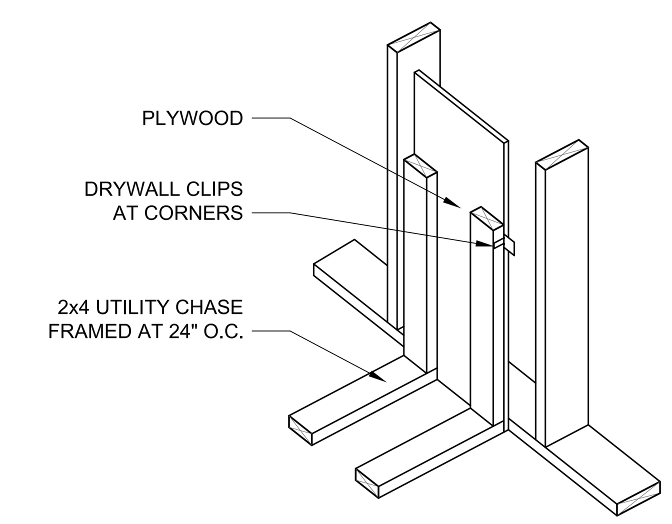
3 SINGLE TOP PLATE AT PARTITION
SCALE: N.T.S.



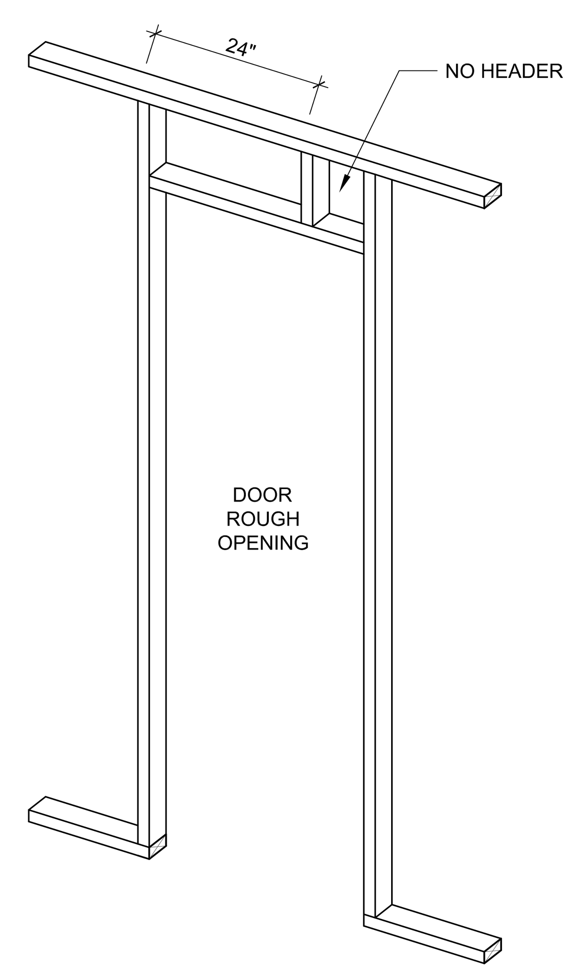
8 TWO-STUD CORNER - BOTTOM
SCALE: N.T.S.



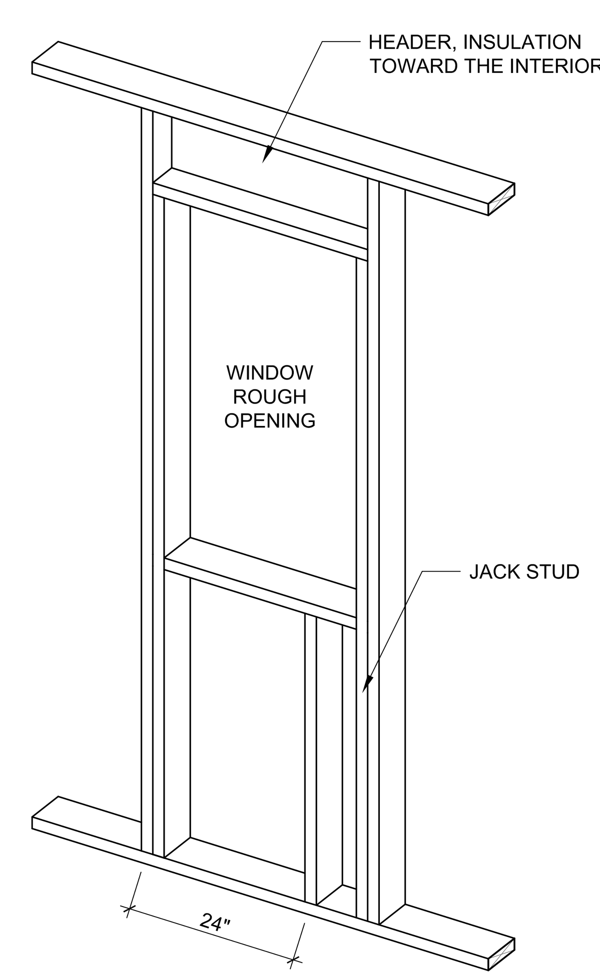
5 BOTTOM PLATE AT PARTITION
SCALE: N.T.S.



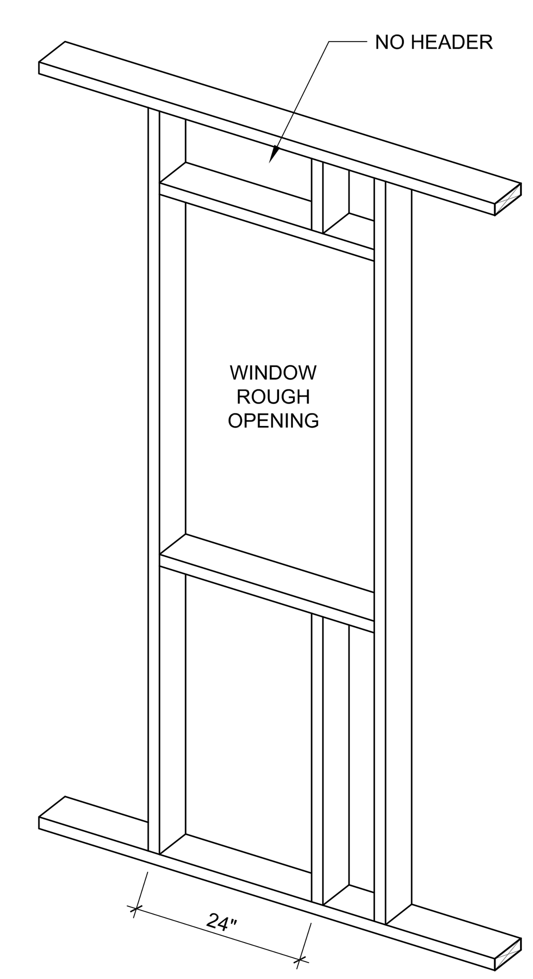
2 CHASE AT EXTERIOR WALL
SCALE: N.T.S.



7 NON-LOAD BEARING INTERIOR WALL
SCALE: N.T.S.



4 LOAD BEARING WALL
SCALE: N.T.S.



1 NON-LOAD BEARING WALL
SCALE: N.T.S.

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