Building Science

Building Science is a multidisciplinary field that encompasses the study of the physical principles and processes involved in the design, construction, operation, and maintenance of buildings. It integrates knowledge from various scientific and engineering disciplines to create structures that are energy-efficient, environmentally sustainable, durable, and comfortable for occupants.

Key aspects of Building Science include:

1. **Thermal Performance:** Understanding how heat moves through building materials and designing structures to optimize insulation and minimize heat loss or gain. This involves considerations like the building envelope, insulation materials, and thermal bridges.

2. **Moisture Management:** Controlling and preventing the infiltration of water and moisture into a building is crucial for maintaining structural integrity and preventing issues such as mold growth. This includes proper ventilation, moisture barriers, and drainage systems.

3. **Air Quality:** Ensuring indoor air quality is vital for the health and well-being of occupants. This involves proper ventilation systems, air filtration, and minimizing the release of pollutants from building materials.

4. **Structural Integrity:** Ensuring that the building structure is robust and can withstand various loads and environmental conditions. This includes factors such as material selection, load-bearing capacity, and seismic considerations.

5. **Energy Efficiency:** Designing and constructing buildings with a focus on energy conservation, utilizing technologies such as high-efficiency HVAC systems, energy-efficient lighting, and renewable energy sources.

Now, when it comes to Healthy Home Building, it involves integrating health and well-being considerations into the building design and construction process. This includes:

1. **Indoor Air Quality:** Prioritizing the use of low-emission materials, proper ventilation, and air filtration systems to ensure that the indoor air is clean and healthy for occupants.

2. **Natural Light and Ventilation:** Incorporating features that maximize natural light and promote natural ventilation, which not only contributes to energy efficiency but also enhances the well-being of occupants.

3. **Non-Toxic Materials:** Avoiding the use of materials that emit harmful substances or off-gas volatile organic compounds (VOCs), which can have adverse effects on indoor air quality and occupant health.

4. **Biophilic Design:** Integrating elements of nature into the built environment, such as indoor plants or natural materials, to promote a connection with nature and improve mental well-being.

5. **Comfort:** Designing for occupant comfort, considering factors such as thermal comfort, acoustics, and ergonomic design.

In summary, Building Science and Healthy Home Building are interconnected fields that aim to create buildings that are not only structurally sound and energy-efficient but also contribute to the overall well-being and health of the occupants.

Here are some videos explaining a couple different applications Sutter Homes does:

Air Quality System Sutter Homes Uses

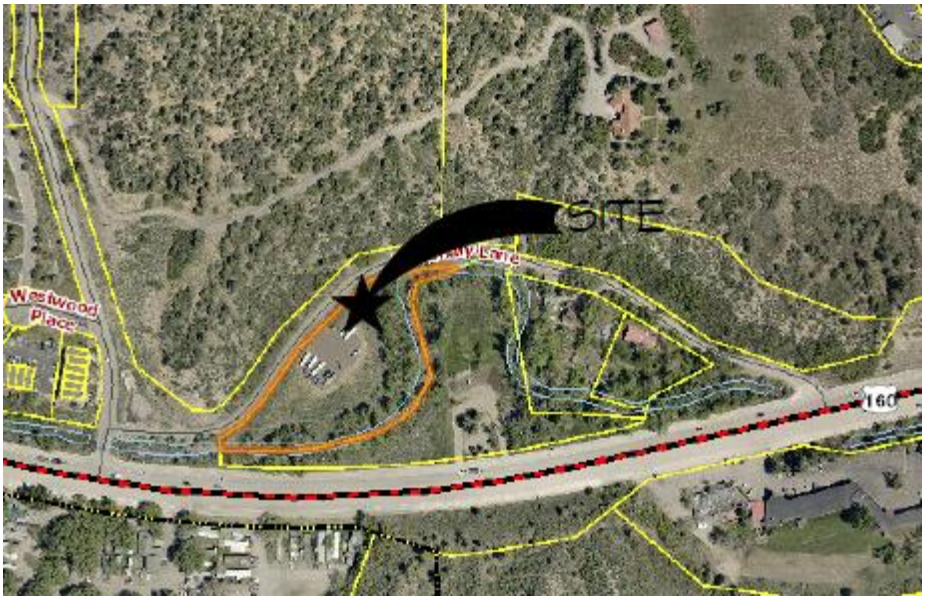
Air Sealing

Lastly attached is a Zero Energy Ready Home Cert for the level of home and third party rating of the product. Please see attached for the current house we are working on

ZERH Preliminary Evaluation

Project: Duhon Residence
209 Rosemary Lane, Durango, Colorado

Date:	November 14, 2023
Submitted to:	Sutter Homes
By:	Mike Frisoni Annadel Building Solutions, LLC 970-533-1548



1.0 Introduction

This report presents the preliminary energy efficiency analysis, and discusses the DOE Zero Energy Ready Home Version 2, Energy Star Version 3.2, EPA Indoor airPLUS Version 1.4 certification requirements and process. Table 1 summarizes the house design details used in the analysis.

Table 1. House Design Details

House Envelope	**Description (3 Level, 1870 sqft, 4 bedroom)**
Exterior Framed Walls	2x6 at 16"oc with R-23 blown fiberglass; R6 ZIP panel at exterior
Lower Floor Concrete Wall	R-22 ICF
Band joist between Floors	R-21 batt; R6 ZIP at exterior
Wall between Entry/Flex Space and Garage	2x6 at 16"oc with R-23 blown fiberglass
Band joist between Entry/Flex Space and	R-21 ccSPF insulation
Ceiling areas	Vented Attic; R-49 blown fiberglass
Windows/Patio Doors	Jeld Win Quote JW2309012SF - Version 0; dated 10/19/2023
Enclosed Crawlspace	R-22 ICF stem wall; ventilation provided by ERV; no insulation at concrete stem walls
Floor above Crawlspace	12" TJI at 16"oc with R-30 batt insulation
Floor above Garage	12" TJI at 16"oc with R-21 ccSPF plus R-19 fiber glass batt
Upper Floor Cantilever	12" TJI at 16"oc with R-21 ccSPF plus R-19 fiber glass batt
Space Heating and Cooling	CH-HPR28M ductless air source heat pump; 11.3HSPF; 22.5 SEER; quantity = 2; 6 head units total
Domestic Hot Water	AO Smith HP 80 gallon water heater; 3.45 UEF (3.57 EF); R-3 on all hot water pipes from tank to each fixture location; Push button demand control of recirculation loop pump; All faucets and showers are water sense (<= 2gpm)
Whole-house Ventilation	Zehnder CAQ600 ERV with MERV 8 or higher filter; (ASHRAE 62.2-2010 continuous ventilation rate = 56 CFM)
Lighting	100 percent LED
Appliances	Appliance list dated 10/20/2023; all appliances must be Energy Star
Ceiling Fans	Ceiling fans must be Energy Star, if applicable
Blower Door Test	<=3 ACH50 per energy code
PV System	6000 Watt array; Southwest orientation; located on 3/12 pitch roof
ERI	**-3** (41 without PV)
House Design UA	**253.7**
ZERH ERI Target Requirement	<= 53
Energy Star ERI Target Requirement	<= 63
2021 IECC UA Requirement	<= 298.9

2.0 ZERH Requirements

The performance requirements for this project are:

1) ERI at construction completion is <= DOE ZERH ERI Target
2) Energy Star Rater Field Checklist (RFC) compliance,
3) Energy Star HVAC Design Report completed,
4) EPA IAP Checklist compliance,
5) ZERH Rater Field Checklist compliance

It is Sutter Homes responsibility to review all the requirements to make sure none are overlooked.

2.1 Energy Star Rater Field Checklist Considerations

The Rater Field Checklist must be completed and signed. The Checklist is verified by both the builder and the rater. The applicable measures are highlighted in Exhibit 1.

2.2 HVAC Design Report and Documentation Requirements

Only Sections 1 through 2 of the HVAC Design Report must be completed, since the space heating/cooling equipment is a ductless minisplit ASHP. Sections 3 and 4 are recommended.

For this house, the ASHRAE 62.2-2010 ventilation metrics for a continuous system are:

1) whole house supply air flow rate is 56 CFM
2) the bathroom exhaust air flow rate is 20 CFM (50 CFM if intermittent)

2.3 EPA Indoor airPLUS Checklist Considerations

The EPA IAP Checklist must be completed and signed. The IAP Checklist is verified by both the builder and the rater. Sutter Homes will be responsible for completing all builder verification items on the IAP Checklist.

2.4 ZERH Rater Field Checklist Considerations

Completion of the ZERH Rater Field Checklist is the responsibility of the Rater, but it is important for Sutter Homes to review and understand these mandatory requirements.

3.0 Summary ZERH Mandatory Requirements

Many of the ZERH requirements are compliant per the details listed in Table 1. The following gives those details that are specific to this project that are not included in Table 1.

3.1 Water Heating Efficiency

For hot water delivery systems, there shall be no more than 0.5 gallons in a pipe branch between the hot water source and the fixture. The ID of the pipe and length of branch will be used to calculate the volume.

The recirculation loop pump will be demand controlled (push button switches or occupancy sensors at each hot water fixture location. Sutter Homes will provide a recirculation loop schematic that defines:

1. the recirculation loop and branch layout
2. the recirculation loop total round trip length in linear feet,
3. the length of the longest branch from loop to fixture in linear feet;
4. volume calculation of longest branch from the recirculation loop to fixture.

During the final rating at post-construction, a test will be conducted at the fixture with the longest branch to demonstrate that no more than 0.6 gallons of water is collected before hot water is delivered to the fixture. There must be a 10 degree F water temperature rise from the time when the collection begins to when the 0.6 gallons are collected.

3.2 Electrical Vehicle Ready

One parking space is provided per dwelling unit that includes a powered 208/240V, 40A receptacle installed in garage or within 3 feet of driveway or dedicated parking space. The electric service panel identifies the branch circuit as "Electric Vehicle Charging."

If the addition of the 40-amp Electric Vehicle Charging branch circuit increases the electrical service to the next nominal size (i.e., from 200-amp to 400-amp service), connecting the circuit to the electrical panel is not required. The conductor shall be labeled as "electrical vehicle charging."

Sutter Homes will provide the Rater with a copy of the electrical sizing calculations or statement from the electrical designer.

3.3 EPA Indoor airPlus

The following lists some of the key Indoor airPlus requirements. Refer to the checklist for the complete list.

- No air handling equipment and ducts within the Garage. If the ERV is located in the Garage, the unit and ducts must be separated from the Garage space by an air barrier (example: air tight closet, mechanical room, and/or soffit; with an air tight access door).
- Clothes dryer vents directly to outdoors.
- CO alarms installed in each sleeping zone.
- Door closer installed at Entry door to Garage.

4.0 Inspections and Performance Testing

4.1 Rough Inspection

The rough inspection is scheduled at completion of rough-in and air sealing, but prior to insulation. This inspection is to verify proper framing and air sealing details have been completed.

The NFRC labels must be present on the windows and glass doors for this inspection.

4.2 Post-Insulation Inspection

The insulation inspection is scheduled at post insulation but prior to drywall. This inspection is to verify proper insulation installation and all other relevant ZERH requirements.

4.3 Final Rating at Post- Construction

The final inspections and performance testing is scheduled at project completion but prior to occupant move-in. All checklists must be completed and signed. The documentation listed below in Section 4.4 must be provided prior to the scheduled final rating date.

4.4 Information Needed Prior to Final Rating

1) Recirculation Loop Schematic (refer to Section 3.1)
2) HVAC Design Report; Sections 1 and 2 are required; Sections 3 and 4 are recommended.
3) Energy Star appliance list (refrigerator, dishwasher, clothes washer and dryer).
4) Energy Star ceiling fan information (need CFM/W at medium speed), if applicable
5) Pictures of ICF stem walls prior to backfill.
6) Documentation providing flow rates of faucets and showerheads (<= 2 gm for HERS Index credit).
7) Pictures of air-sealing details per the Rater Field Checklist, as applicable. This will be determined at the Rough Inspection.

EXHIBIT 1. Rater Field Checklist Applicable Requirements (highlighted in yellow)

ENERGY STAR Single-Family New Homes
National Rater Field Checklist, Version 3 / 3.1 / 3.2 (Rev. 12)

Home Address: _____ City: _____ State: _____ Permit Date: _____

Thermal Enclosure System **1. High-Performance Fenestration & Insulation**	Must Correct	Builder Verified [1]	Rater Verified [2]	N/A [3]
1.1 Fenestration meets or exceeds specification in Item 2.1 of the National Rater Design Review Checklist.	☐	☐	☐	-
1.2 Insulation meets or exceeds specification in Item 3.1 of the National Rater Design Review Checklist. [4]	☐	☐	☐	-
1.3 All insulation achieves Grade I install. per ANSI / RESNET / ICC 301. Alternatives in Footnote 5. [5,6]	☐	☐	☐	-
2. Fully-Aligned Air Barriers [7] - At each insulated location below, a complete air barrier is provided that is fully aligned as follows:				
Ceilings: At interior or exterior horizontal surface of ceiling insulation in Climate Zones 1-3; at interior horizontal surface of ceiling insulation in Climate Zones 4-8. Also, at exterior vertical surface of ceiling insulation in all climate zones (e.g., using a wind baffle that extends to the full height of the insulation in every bay or a tabbed baffle in each bay with a soffit vent that prevents wind washing in adjacent bays). [8]				
2.1 Dropped ceilings / soffits below unconditioned attics, and all other ceilings.	☐	☐	☐	☐
Walls: At exterior vertical surface of wall insulation in all climate zones; also at interior vertical surface of wall insulation in Climate Zones 4-8. [9]				
2.2 Walls behind showers, tubs, staircases, and fireplaces.	☐	☐	☐	☐
2.3 Attic knee walls and skylight shaft walls. [10]	☐	☐	☐	☐
2.4 Walls adjoining porch roofs or garages.	☐	☐	☐	☐
2.5 Double-walls and all other exterior walls.	☐	☐	☐	-
Floors: At exterior vertical surface of floor insulation in all climate zones and, if over unconditioned space, also at interior horizontal surface including supports to ensure alignment. Alternatives in Footnotes 12 & 13. [11, 12, 13]				
2.6 Floors above garages, floors above unconditioned basements or crawlspaces, and cantilevered floors.	☐	☐	☐	☐
2.7 All other floors adjoining unconditioned space (e.g., rim / band joists at exterior wall or at porch roof).	☐	☐	☐	☐
3. Reduced Thermal Bridging				
3.1 For insulated ceilings with attic space above (i.e., non-cathedralized), Grade I insulation extends to the inside face of the exterior wall below and is ≥ R-21 in CZ 1-5; ≥ R-30 in CZ 6-8. [14]	☐	☐	☐	☐
3.2 For slabs on grade in CZ 4-8, 100% of slab edge insulated to ≥ R-5 at the depth specified by the 2009 IECC and aligned with the thermal boundary of the walls. [15, 16]	☐	☐	☐	☐
3.3 Insulation beneath attic platforms (e.g., HVAC platforms, walkways) ≥ R-21 in CZ 1-5; ≥ R-30 in CZ 6-8.	☐	☐	☐	☐
3.4 At above-grade walls separating conditioned from unconditioned space, one of the following options used (rim / band joists exempted): [17]				
3.4.1 Continuous rigid insulation, insulated siding, or combination of the two is: ≥ R-3 in CZ 1-4; ≥ R-5 in CZ 5-8 [18, 19, 20], **OR**;	☐	☐	☐	☐
3.4.2 Structural Insulated Panels **OR**; Insulated Concrete Forms **OR**; Double-wall framing **OR**; [18, 21]	☐	☐	☐	☐
3.4.3 Advanced framing, including all of the Items below: [22]				
3.4.3a Corners insulated ≥ R-6 to edge [23], **AND**;	☐	☐	☐	☐
3.4.3b Headers above windows & doors insulated ≥ R-3 for 2x4 framing or equivalent cavity width, and ≥ R-5 for all other assemblies (e.g., with 2x6 framing) [24], **AND**;	☐	☐	☐	☐
3.4.3c Framing limited at all windows & doors to one pair of king studs, plus one pair of jack studs per window opening to support the header and sill, **AND**;	☐	☐	☐	☐
3.4.3d Interior / exterior wall intersections insulated to same R-value as rest of exterior wall, [25] **AND**;	☐	☐	☐	☐
3.4.3e Minimum stud spacing of 16 in. o.c. for 2x4 framing in all Climate Zones and, in CZ 6-8, 24 in. o.c. for 2x6 framing. [26]	☐	☐	☐	☐
4. Air Sealing (Unless otherwise noted below, "sealed" indicates the use of caulk, foam, or equivalent material)				
4.1 Ducts, flues, shafts, plumbing, piping, wiring, exhaust fans, & other penetrations to unconditioned space sealed, with blocking / flashing as needed.	☐	☐	☐	-
4.2 Recessed lighting fixtures adjacent to unconditioned space ICAT labeled and gasketed. Also, if in insulated ceiling without attic above, exterior surface of fixture insulated to ≥ R-10 in CZ 4-8.	☐	☐	☐	☐
4.3 Above-grade sill plates adjacent to conditioned space sealed to foundation or sub-floor. Gasket also placed beneath above-grade sill plate if resting atop concrete / masonry & adjacent to cond. space. [27,28]	☐	☐	☐	☐
4.4 Continuous top plate or blocking is at top of walls adjoining unconditioned space, and sealed.	☐	☐	☐	☐
4.5 Drywall sealed to top plate at all unconditioned attic / wall interfaces using caulk, foam, drywall adhesive (but not other construction adhesives), or equivalent material. Either apply sealant directly between drywall and top plate or to the seam between the two from the attic above.	☐	☐	☐	☐
4.6 Rough opening around windows & exterior doors sealed. [29]	☐	☐	☐	-
4.7 Walls that separate attached garages from occupiable space sealed and, also, an air barrier installed and sealed at floor cavities aligned with these walls.	☐	☐	☐	☐
4.8 In multifamily buildings, the gap between the common wall (e.g., the drywall shaft wall) and the structural framing between units sealed at all exterior boundaries.	☐	☐	☐	☐
4.9 Doors adjacent to unconditioned space (e.g., attics, garages, basements) or ambient conditions made substantially air-tight with weatherstripping or equivalent gasket.	☐	☐	☐	☐
4.10 Attic access panels, drop-down stairs, & whole-house fans equipped with durable ≥ R-10 cover that is gasketed (i.e., not caulked). Fan covers either installed on house side or mechanically operated. [30]	☐	☐	☐	☐

HVAC System [31]				Must Correct	Rater Verified [2]	N/A [3]
5. Heating & Cooling Equipment - Complete Track A - HVAC Grading [32] or Track B - HVAC Credential [33]						
Track A	5a.1 Blower fan volumetric airflow is Grade I or II per ANSI / RESNET / ACCA / ICC 310.			☐	☐	☐
	5a.2 Blower fan watt draw is Grade I or II per ANSI / RESNET / ACCA / ICC 310.			☐	☐	☐
	5a.3 Refrigerant charge is Grade I per ANSI / RESNET / ACCA / ICC 310. See Footnote 34 for exemptions.[34]			☐	☐	☐
Track B	5b.1 HVAC manufacturer & model number on installed equipment matches either of the following (check box):[35] ☐ National HVAC Design Report ☐ Written approval received from designer			☐	☐	☐
	5b.2 External static pressure measured by Rater at contractor-provided test locations and documented below:[36] Return-Side External Static Pressure: _____IWC Supply-Side External Static Pressure: _____IWC			☐	☐	☐
	5b.3 Permitted, but not required: National HVAC Commissioning Checklist collected, with no items left blank.			☐	☐	☐
6. Duct Quality Installation (Applies to Heating, Cooling, Ventilation, Exhaust, & Pressure Balancing Ducts, Unless Noted in Footnote)						
6.1 Ductwork installed without kinks, sharp bends, compressions, or excessive coiled flexible ductwork. [37]				☐	☐	☐
6.2 Bedrooms pressure-balanced (e.g., using transfer grilles, jump ducts, dedicated return ducts, undercut doors) to achieve a Rater-measured pressure differential ≥ -3 Pa and ≤ +3 Pa with respect to the main body of the house when all air handlers are operating. Test configuration and an alternative compliance option in Footnote 38. [38]				☐	☐	-
6.3 All supply and return ducts in unconditioned space, including connections to trunk ducts, are insulated to ≥ R-6 [39]				☐	☐	☐
6.4 Rater-measured total duct leakage meets one of the following two options. Alternative in Footnote 41: [40, 41, 42]						
6.4.1 Rough-in: The greater of ≤ 4 CFM25 per 100 sq. ft. of CFA or ≤ 40 CFM25, with air handler & all ducts, building cavities used as ducts, & duct boots installed. All duct boots sealed to finished surface, Rater-verified at final. [43]				☐	☐	☐
6.4.2 Final: The greater of ≤ 8 CFM25 per 100 sq. ft. of CFA or ≤ 80 CFM25, with the air handler & all ducts, building cavities used as ducts, duct boots, & register grilles atop the finished surface (e.g., drywall, floor) installed. [44]				☐	☐	☐
6.5 Rater-measured duct leakage to outdoors the greater of ≤ 4 CFM25 per 100 sq. ft. of CFA or ≤ 40 CFM25. [40, 45]				☐	☐	☐
7. Dwelling Unit Mechanical Ventilation Systems ("Vent System") [46] & Inlets in Return Duct [47]						
7.1 Rater-measured ventilation rate is within either ± 15 CFM or ±15% of design report value. [48]				☐	☐	-
7.2 A readily-accessible ventilation override control installed and also labeled if its function is not obvious (e.g., a label is required for a toggle wall switch, but not for a switch that's on the ventilation equipment). [49]				☐	☐	-
7.3 For any outdoor air inlet connected to a ducted return of the HVAC system (Complete if present; otherwise check "N/A"): [47]						☐
7.3.1 Controls automatically restrict airflow using a motorized damper during vent. off-cycle and occupant override. [50]				☐	☐	-
7.3.2 Rater-measured vent. rate is ≤ 15 CFM or 15% above design value at highest HVAC fan speed. Alt. in Fn. 51. [51]				☐	☐	-
7.4 System fan rated ≤ 3 sones if intermittent and ≤ 1 sone if continuous, or exempted. [52]				☐	☐	-
7.5 If Vent System controller operates the HVAC fan, then HVAC fan operation is intermittent and either the fan type is ECM / ICM or the controls will reduce the run-time by accounting for HVAC system heating or cooling hours. [53]				☐	☐	☐
7.6 Bathroom fans are ENERGY STAR certified if used as part of the Vent System. [54]				☐	☐	☐
7.7 Air inlet location (Complete if ventilation air inlet location was specified on design report; otherwise check "N/A"): [55, 56]						☐
7.7.1 Inlet pulls ventilation air directly from outdoors and not from attic, crawlspace, garage, or adjacent dwelling unit.				☐	☐	-
7.7.2 Inlet is ≥ 2 ft. above grade or roof deck; ≥ 10 ft. of stretched-string distance from known contamination sources not exiting the roof, and ≥ 3 ft. distance from dryer exhausts and sources exiting the roof. [57]				☐	☐	-
7.7.3 Inlet is provided with rodent / insect screen with ≤ 0.5 inch mesh.				☐	☐	-
8. Local Mechanical Exhaust – In each kitchen and bathroom, a system is installed that exhausts directly to the outdoors and meets one of the following Rater-measured airflow and manufacturer-rated sound level standards: [48, 58]						
Location		**Continuous Rate**	**Intermittent Rate [59]**			
8.1 Kitchen	Airflow	≥ 5 ACH, based on kitchen volume [60, 61]	≥ 100 CFM and, if not integrated with range, also ≥ 5 ACH based on kitchen volume [60, 61, 62]	☐	☐	-
	Sound	Recommended: ≤ 1 sone	Recommended: ≤ 3 sones			
8.2 Bathroom	Airflow	≥ 20 CFM	≥ 50 CFM	☐	☐	-
	Sound	Required: ≤ 1 sone	Recommended: ≤ 3 sones			
9. Filtration						
9.1 MERV 6+ filter(s) installed in each ducted mech. system, designed so all return and mechanically supplied outdoor air passes through filter(s) prior to conditioning, and located to facilitate occupant access & regular service. [63]				☐	☐	☐
9.2 Filter access panel includes gasket and fits snugly against exposed edge of filter when closed to prevent bypass. [64]				☐	☐	☐
10. Combustion Appliances						
10.1 Furnaces, boilers, & water heaters are mechanically drafted or direct-vented. Alternatives in Footnote 67. [65, 66, 67]				☐	☐	☐
10.2 Fireplaces are mechanically drafted or direct-vented. Alternatives in Footnote 68. [65, 66, 68]				☐	☐	☐
10.3 No unvented combustion appliances other than cooking ranges or ovens are located inside the home's pressure boundary. Alternative in Footnote 70. [65, 69, 70]				☐	☐	☐

Rater Name: _____ Rater Pre-Drywall Inspection Date: _____ Rater Initials: _____

Rater Name: _____ Rater Final Inspection Date: _____ Rater Initials: _____

Builder Employee: _____ Builder Inspection Date: _____ Builder Initials: _____

* MERV 8+