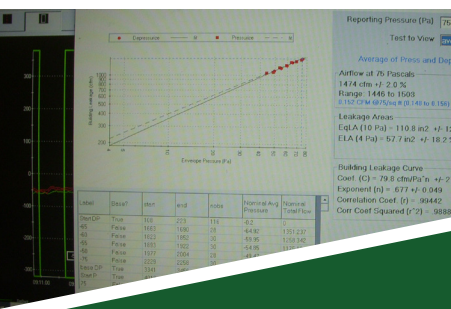
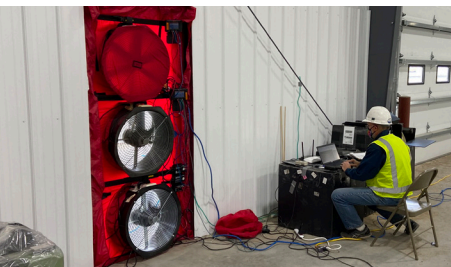
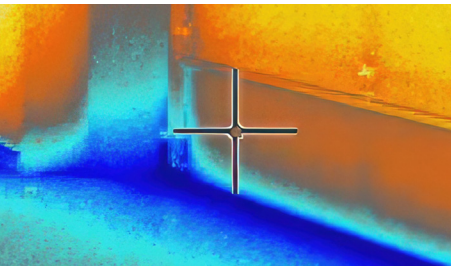


Best Practices to Comply With Whole-Building Air Leakage Testing Requirements For Metal Building Systems



Best Practices to Comply With Whole-Building Air Leakage Testing Requirements For Metal Building Systems

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This document (the “Guide”) was created with a goal of identifying practices for metal building manufacturers and contractors to improve the chances of having metal buildings pass whole-building air leakage testing requirements. The Guide is intended to serve as a general educational aid and includes information about protocols and processes that have been studied by the Metal Building Manufacturers Association (“MBMA”), the North American Insulation Manufacturers Association (“NAIMA”), the Door & Access Systems Manufacturers Association (“DASMA”) and Z-tech Consulting LLC (“Author”). MBMA, NAIMA, DASMA, and the Author have made reasonable efforts to be accurate and comprehensive in the creation of the Guide. Readers of the Guide should be aware that developments with regard to whole-building air leakage occur regularly and should not assume that all Guide content represents the current state of practice.

MBMA, NAIMA, DASMA, and the Author do not promise or warrant that following the recommendations of this Guide will necessarily result in a structure passing any particular whole-building air leakage testing requirement. Each manufacturer and contractor should make its own independent decisions exercising its own judgment to ensure compliance with building codes and all applicable laws, codes, and regulations.

Best Practices to Comply With Whole-Building Air Leakage Testing Requirements For Metal Building Systems

Executive Summary

Metal Building System (MBS) construction has been found to perform well in whole-building air leakage testing sponsored by the Metal Building Manufacturers Association (MBMA), the North American Insulation Manufacturers Association (NAIMA), and the Door & Access Systems Manufacturers Association (DASMA). This testing demonstrated why results exceeded expectations and highlighted that performance of these buildings can reach any level likely to be specified by code or high-performance building standards through implementation of best practices.

These best practices are drawn from the air leakage testing performed in the field, which has shown that certain parts of the building need special attention. They are listed below and are shown in Figure 1.

- **Dissimilar Material Interfaces:** wall bases, personnel doors, windows, and overhead doors.
- **Intersections/changes in air barrier configuration:** wall-to-roof interfaces, wall corners, etc.
- **Penetrations:** Canopy framing members, mechanical (HVAC), electrical, plumbing (MEP), etc.

The testing program clearly shows that MBS construction can readily comply with air leakage testing requirements implemented in current codes, including high-performance and stretch codes. It also indicates that implementation of the best practices included here can bring the Continuous Air Barrier (CAB) performance to even more stringent levels, positioning MBS construction as a leading option for energy-efficient buildings now and in the future.

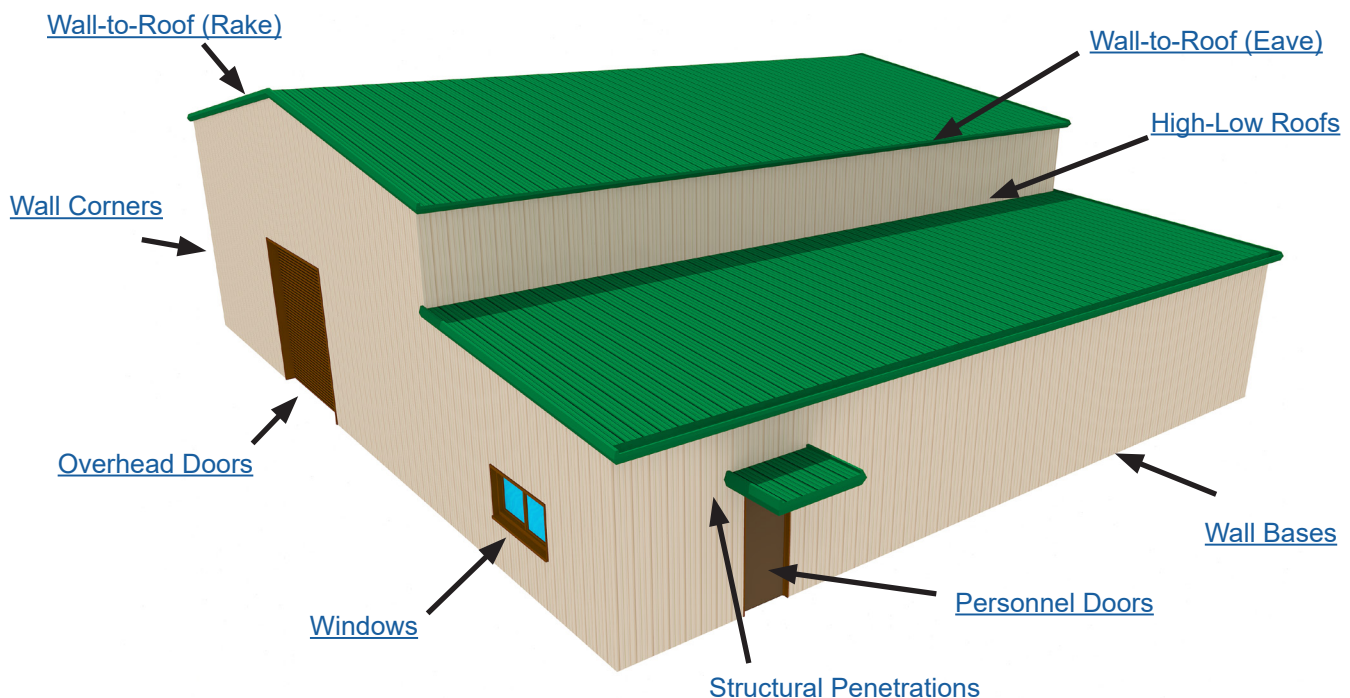


Figure 1: Areas Requiring Special Attention

Within the document, the best practices and supportive actions are presented in sequential order as follows:

Pre-Construction Activities:

- [Pre-Construction Detail Review](#) – The best way to solve a problem is to eliminate it as a possibility.

Construction Activities:

- [Foundation and Anchorage](#) – A few but impactful tips to help performance.
- [Primary and Secondary Framing](#) – Surface prep is key to good CAB installation.
- Walls, including [base conditions](#), [panel and insulation installation](#), [corner conditions](#), and [roof-to-wall interfaces](#). This section is focused on CAB continuity.
- Accessory installation, including [windows](#), [personnel doors](#), and [overhead doors](#), all of which were found to be important performance factors.
- [Roofs](#), including [high-low transitions](#), which are difficult to access on test day.
- [Penetrations](#) for mechanical, electrical, and plumbing (MEP) as well as structural materials can be numerous and significantly impact performance.
- [Quality Control/Quality Assurance](#) – Built primarily from test agency feedback and testing participants, these steps ensure testing will go smoothly.

Additionally, some helpful information is provided in the appendices:

- [Appendix A](#) provides a project checklist.
- [Appendix B](#) is dedicated to overhead door installation.
- [Appendix C](#) gives background information on applicable codes, test methods, and general material requirements.

Best Practices for MBS Construction

This document uses the term “Inboard” to describe systems where the CAB lies to the interior side of the secondary framing, and “Outboard” to describe systems where the CAB lies between the secondary framing and the exterior cladding. Figures in the document use **blue** lines to depict the CAB of inboard systems and **red** lines for outboard systems. Where the CAB is **black**, the detail is indifferent to CAB location.

Pre-Construction Detail Review

It is essential that the installer of the CAB review all details prior to commencement of construction to ensure that:

- The materials which are part of the CAB for the system are clearly identified and designated as such on the plans.
- All trades involved in the implementation of a specific detail are identified and the referenced installers have a copy of those details.
- All trades understand that a whole-building air leakage test will be performed on the building.
- The party responsible for post-installation CAB repairs is clearly identified before subsequent work commences.

Construction and Installation

This section provides specific best practices organized roughly by installation sequence.

Foundation and Anchorage

Ensure that concrete slabs or foundation walls near the edge of the building have surfaces appropriate for the base seal method specified in the CAB details. (i.e., no exposed aggregate or extremely rough finishes) If a sheeting ledge is present, ensure that it is deep enough to accept the base trim without bottoming out.

Primary and Secondary Framing

If needed, clean and smooth surfaces of welded components such as main frames and frame opening jambs which will receive CAB tape. This is especially true for excessive weld splatter, which may cause CAB tape to unseat over time.

Wall Base/Trim

Pay close attention to exterior wall bases as they are significant contributors to poor air barrier performance. Generally, base details provided by metal building manufacturers show CAB components in contact with framing but may not explicitly describe how to handle adjoining materials. Additional coordination may be needed.

Identify and locate all CAB materials including fasteners with washers, tape sealant, flashing, and CAB tape. Note that foam closures are usually not an essential part of a CAB, but they have been shown to reduce air leakage when used.

Figure 2 shows an MBS wall base detail. Note the following:

1. The continuous bead of sealant under the base angle sits outboard of the base member anchorage. Apply additional sealant to fill the base angle butt joints if the continuous seal does not extrude to a level even with the base angle surface.
2. The base trim is secured to the base angle with a low-profile fastener which will not perforate the insulation facing.
3. A horizontal continuous line of CAB tape seals the facing/base trim interface.
4. Use a piece of CAB tape to close base angle butt joints. CAB tape should be continuous from the horizontal tape line past the base continuous seal but should stop before the concrete anchor.

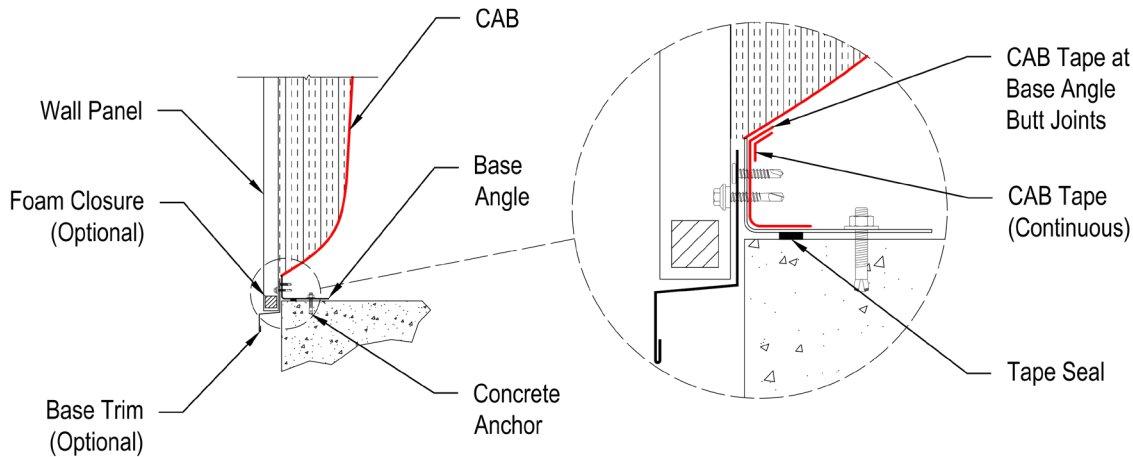


Figure 2: Base Detail with Faced Insulation

Any piece of trim which is part of the air barrier such as the base trim in Figure 2 should be lapped 1 to 3 inches with a line of tube or tape butyl sealant.

Wall Panel/Insulation Installation

If a sealed wall panel system is used, ensure the following:

- Tape seals are centered over the wall panel rib in the side laps and the tape lines are as straight as possible. A $\frac{3}{4}$ to 1-inch width tape often gives better results than narrower versions.
- Butt ends of adjacent tape seal are joined and closed.
- Ensure that the panel side lap fasteners have washers and penetrate the sealant between panel plies.
- Fasteners are placed as close to the wall panel rib center line as possible to ensure proper sealant engagement. Pre-drilled holes allow easy visual inspection of the exposed tape.
- For tall buildings with end laps, a second line of transverse tape seal applied to the interior side of the joint is cheap insurance against air leakage. If a wainscot is present, ensure end closures are used above and below the transition trim.
- End closures are used at the wall base and eave.

Unsealed wall systems install faster and are more forgiving. However, the insulation facing now becomes the primary CAB and has no backup, placing even more importance on proper installation.

For outboard CAB systems, care must be taken to not damage the facing during panel installation. Generally, the panel and insulation are installed simultaneously with the insulation running 2 to 6 feet ahead of the panel. This is a good practice as it protects the exposed facing. Facing joints for outboard CAB systems may be taped or folded and tucked. Liners are generally taped. All perform well when properly installed.

Inboard CAB systems may be installed during or after panel installation and are generally taped. Again, the installer should verify the tab dimension is correct before installation begins. Inboard CAB systems require facing or liner continuity through the rigid frame, which itself becomes part of the CAB. If the walls have bypass girts, the facing or liner should tie to the inside face of the frame outer flange. For flush girts, the CAB may be tied to the web of the frame, which may be a difficult connection to make. Either way, the frame should be clear of weld splatter and be free of grease or dirt where the tape connects.

Wall Corners and Roof-To-Wall Interfaces

While there are many different types of insulation systems commonly used on metal roofs, treatment of the CAB is very similar to that of walls. Either the CAB is inboard or outboard of the roof framing and CAB continuity must be maintained in the transition from the wall to the roof. This may be straightforward when both systems are inboard or outboard but maintaining CAB continuity with mixed systems is more difficult. Figure 3 depicts a basic eave detail. These details have been shown to perform very well. CAB continuity is built in for outboard CAB systems as the eave strut provides a convenient landing surface for the tape. Two possible tape treatments are shown in Figure 3, however, taping directly to the eave strut requires that any holes punched in the eave strut without bolts be taped as well.

Outboard systems generally require strapping to support the roof facing or liner. If the wall system is also outboard, the strapping for the roof should be installed first, and then the wall CAB should be brought up to the level of the roof CAB and secured into place with tape.

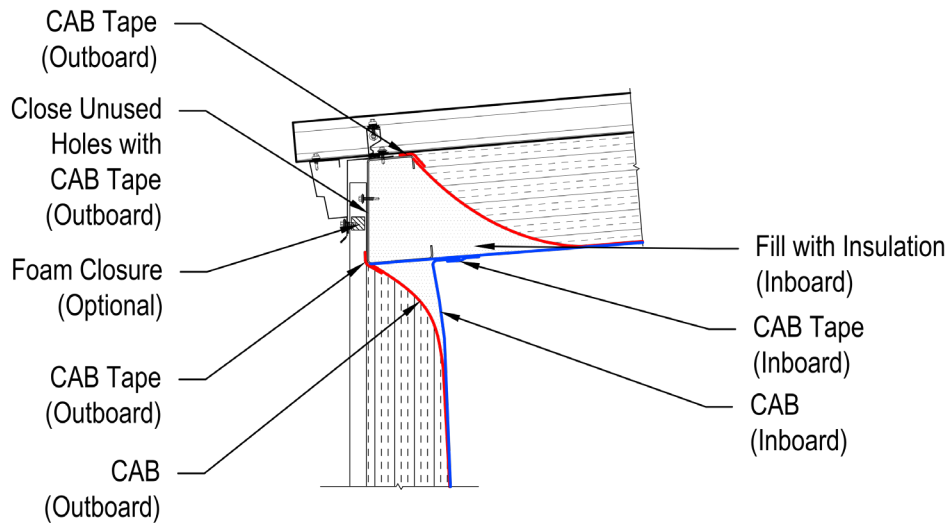


Figure 3: Roof-To-Wall Interface - Eave

Roof-to-wall interfaces at end walls (rakes) can be problematic but the detail shown in Figure 4 addresses the most common problems. Because there is no continuous framing member other than the rake angle, a narrow piece of facing can be installed joining the roof and wall CAB and secured with tape. When this is done, the now-covered roof and wall insulation facings should be perforated to prevent condensation from getting trapped inside the cavity.

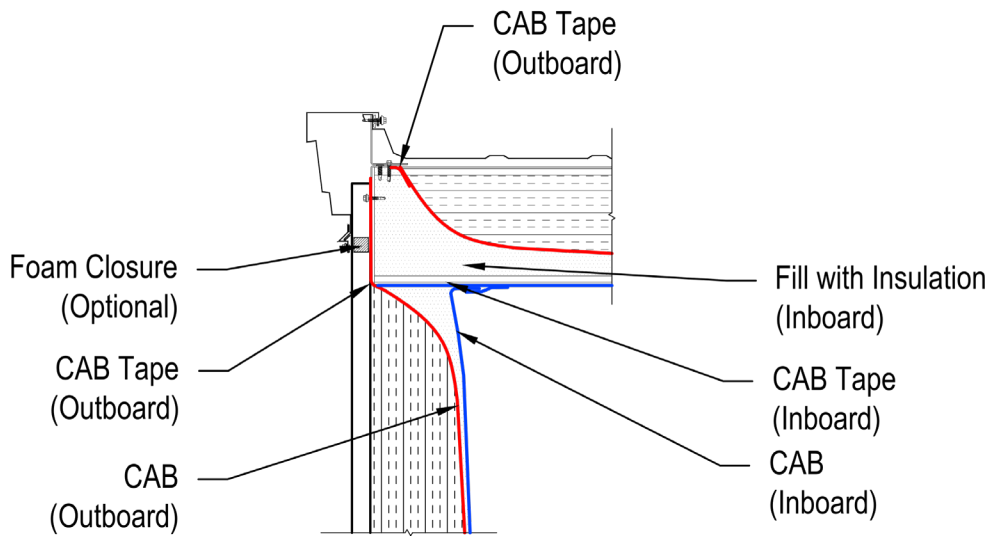


Figure 4: Roof-To-Wall Interface - Rake

As wall installation progresses with outboard systems, the installer must prepare certain areas using special CAB treatments ahead of the progress boundary. Examples are eaves, rakes, and wall corners. Figure 5 and Figure 6 show suggested CAB treatments in these areas.

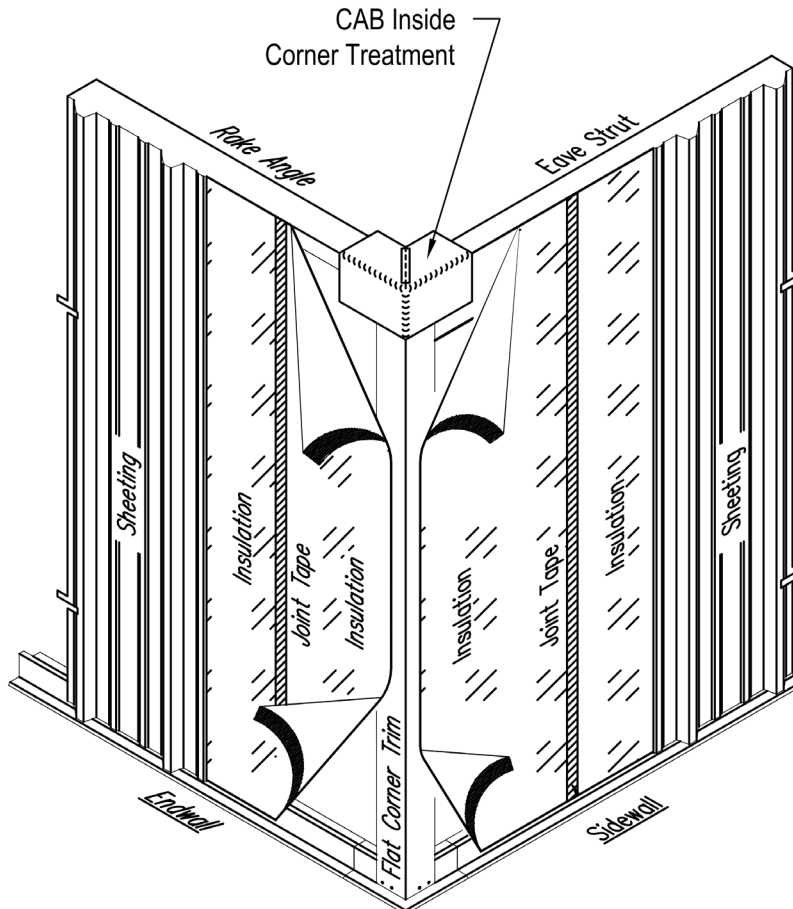


Figure 5: Possible CAB Treatments for Wall Interfaces

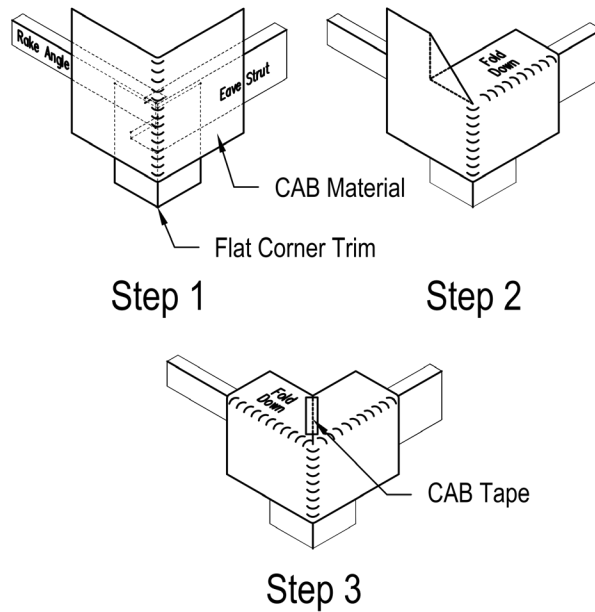


Figure 6: Wall Corner Air Barrier Treatment

The outboard treatments shown above are not necessary for inboard CAB systems, but a piece of trim mounted on the inside flange of the framing member provides a surface for tape and a clean look. However, care should be taken that this landing trim does not introduce a thermal bridge, creating condensation problems.

Windows

CAB continuity around windows is difficult to achieve for any type of construction and this is one of the most cited reasons for air leakage. However, windows developed specifically for use in MBS often do not require a framed opening and are far less problematic. Most manufacturers will provide such windows in addition to the necessary sealing materials. Therefore, these windows should be used whenever possible. Figure 7 and Figure 8 show sections through the window head and sill respectively and Figure 9 shows a jamb section. However, if specific details have been provided, they should be used.

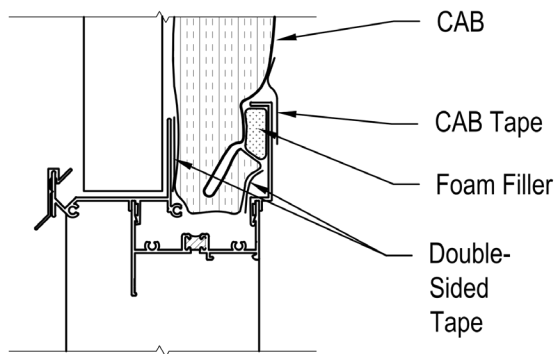


Figure 7: MBS Window Header Section

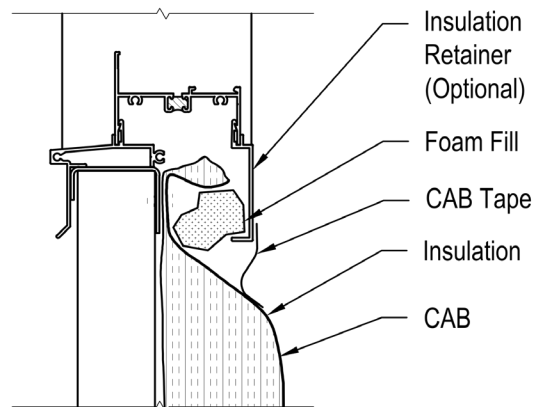


Figure 8: MBS Window Sill Section

MBS windows have the option of a snap-in insulation retainer. When used, this retainer provides a convenient landing surface for CAB tape. If the retainer is not used, then a small amount of foam can be used to close off any gaps.

A detail for a window with a framed opening is shown in Figure 10. This situation occurs when either generic windows are used or with MBS windows in high-wind conditions which require a framed opening. Generic windows are sensitive to framed opening dimensions and may present a challenge when field fit is not as expected. Again, expanding foams can be very helpful to close any gaps.

When framed openings are needed, the insulation facing treatment is different for outboard and inboard CAB conditions. The outboard facing condition is shown in blue, and the inboard condition is shown in red. In the inboard condition, optional cover trim for the framed opening material can be used to hide the CAB tape and provide a sleeker look if exposed to view.

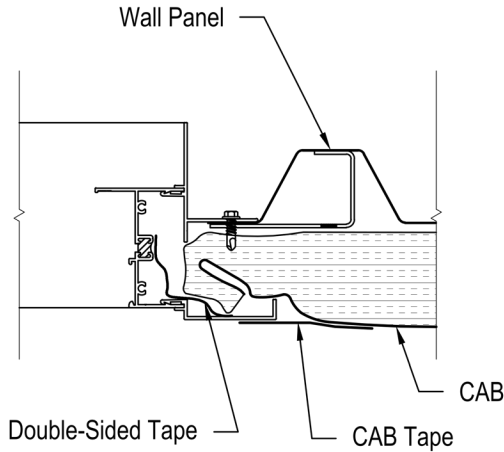


Figure 9: MBS Window Jamb Section

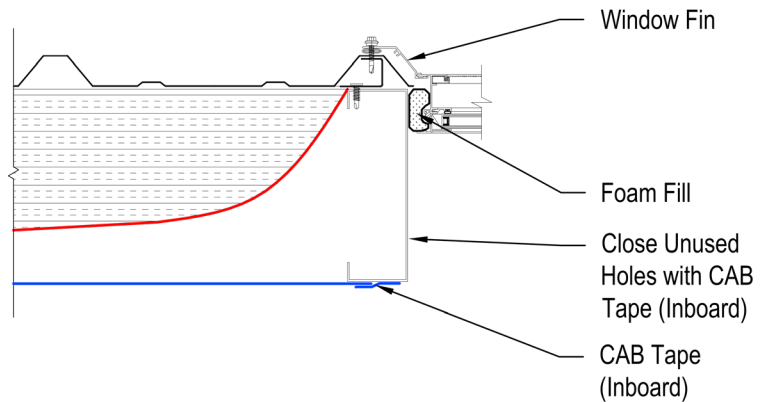


Figure 10: Generic Window Jamb Section

Personnel Doors

Much like windows, MBS-specific personnel doors are available and usually supplied with the building. These doors and their ancillary materials have been tested for use as a system and should be used whenever possible. Figure 11 and Figure 12 show illustrative sections through the door header and jamb respectively, along with separate CAB tape treatments for inboard and outboard systems. However, if specific details have been provided, they should be used.

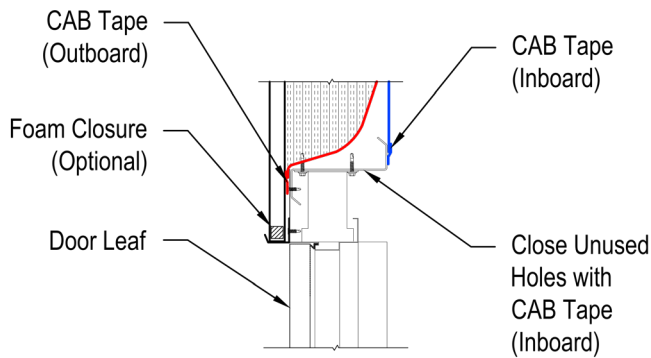


Figure 11: MBS Personnel Door Header Section

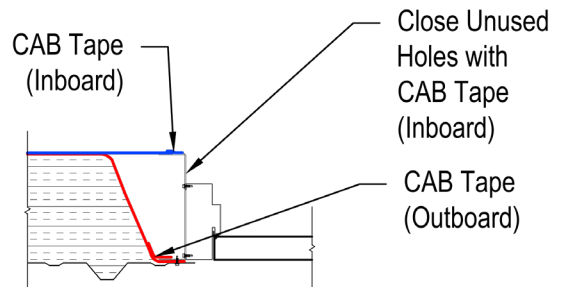


Figure 12: MBS Personnel Door Jamb Section

Overhead Doors

Overhead doors are very common in MBS construction, and like MBS-specific doors and windows, they are tested as an assembly to meet specific air leakage requirements. Both IECC and ASHRAE 90.1 require overhead doors enclosing a conditioned space be tested to DASMA 105 and provide maximum leakage rates.

However, because these doors always require a framed opening and do not have sub-framing members specific to MBS attachment, the CAB treatment adjacent to the jambs and headers must generally be addressed separately. This is a common oversight and a prominent reason cited for air leakage.

It is important to identify inboard versus outboard CAB systems around large framed openings because the CAB treatments around them are quite different. Figure 13 shows a section through the jamb of a typical overhead door with potential CAB treatments corresponding to inboard and outboard CAB systems, with an expandable foam option for outboard CAB systems. [Appendix B](#) provides additional information for sectional and rolling overhead doors.

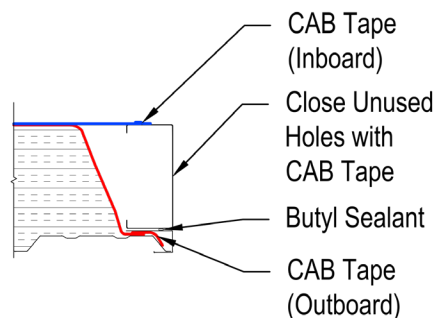


Figure 13: Section Through Overhead Door Jamb

Roofs

Continuous-plane roofs without penetrations are rarely sources of significant air leakage because they are designed to be watertight. When the manufacturer's recommended installation methods and sequence is followed, the installer should have high confidence the roof will perform well in the whole-building test. Therefore, the installer should focus attention on preventative actions performed prior to dry-in, especially with wall-to-roof interfaces (i.e., eaves and rakes) as well as high-low conditions and penetrations.

High-Low Roofs

High-low roofs are nothing more than a transition from a roof to a wall and then back to a roof at a lower elevation. All best practices previously discussed apply and should produce excellent results. Yet, this condition is a commonly cited source of leakage in a whole-building test. Figure 14 shows a sample detail of this condition. Typically, any insulation to the exterior of the girt and purlin will be cut with 10 to 18 inches additional length during installation of the upper wall and lower roof. The fiberglass is later removed from the exposed ends to create tabs. Fill insulation is placed to fill any voids and the tabs are folded and stapled together. CAB tape may also be used. However, when either the roof or upper wall CAB is inboard, a separate facing or liner piece secured with tape may be used to join the roof and wall CAB. Then strapping can be installed to support the facing and prevent it from tearing loose.

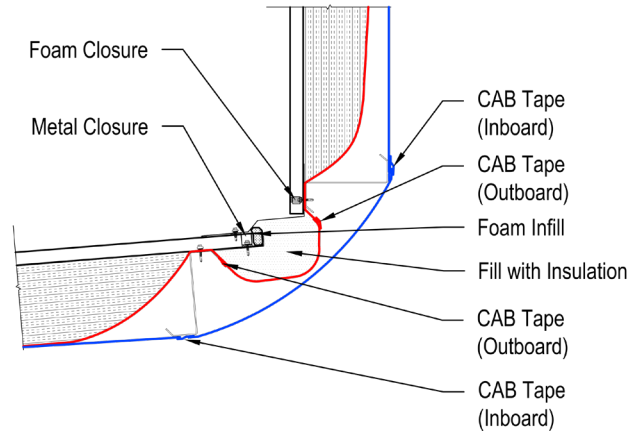


Figure 14: High-Low Roof Tie-In

Penetrations

Penetrations made for ductwork are also a source of infiltrating air. Flashing is essential for these types of penetrations. It is very difficult, if not impossible, for a hole to be cut to fit ductwork exactly, and even if it could be done, thermal expansion and contraction will eventually open voids. Fortunately, this scenario is readily addressed by intentionally cutting the hole slightly larger than the duct and using double-break metal trim secured through butyl tape to close the gap. Then open-cell foam or mineral wool backfill can be used to fill the gap as shown in Figure 15. If desired, additional trim applied to the interior can be used to hide the foam or mineral wool.

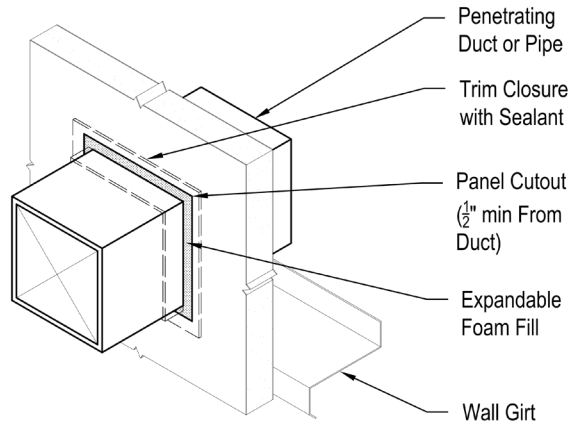


Figure 15: Duct Penetration Detail

Smaller ductwork, however, may have simpler options. Many of the liner system manufacturers have accessories to trim and seal penetrations readily available on their websites. These materials are designed to work in conjunction with the liner and are quick and easy to install.

While any single pipe, conduit or structural member penetration is relatively small and seemingly easy to treat, there could be hundreds of such penetrations in a building and their impacts add up quickly. Figure 16 shows a detail addressing CAB repair for a pipe or circular duct.

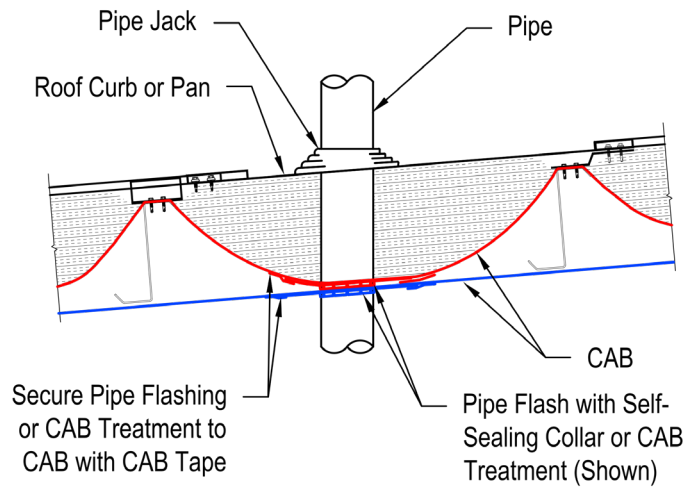


Figure 16: Detail for Roof Pipe Penetration

Much like small ductwork penetrations, liner system manufacturers offer accessories to readily trim and close these penetrations. Figure 17 depicts several of these products for both flange braces and pipe hangers. These penetrations are minor individually, but a large building may have 1,000 or more of them.



Figure 17: Flange Brace and Pipe Hanger CAB Options

Quality Control/Quality Assurance

As with any construction site activity, quality control and quality assurance measures are necessary to ensure that the desired CAB performance is achieved. Fortunately, most of the best practices presented here are readily verified by simple visual inspection, provided it occurs prior to the subject areas being covered by interior finishes or other materials. Furthermore, documenting the findings of this inspection will help the test agency troubleshoot any problems found during execution of the whole-building test.

A best practice is to have the party responsible for CAB installation present during the whole-building test, so any feedback provided by the test agency can be used for training and development of CAB installers. The project checklist presented in [Appendix A](#) includes this and other recommendations to make the whole-building test and related energy code compliance go smoothly.

Appendix A – MBS Air Leakage Performance Project Checklist

1.0 Design Activities

1.1 Building Specification/Schematic Design

- A. Establish energy performance goals for the project in terms of baseline code performance. (For example, “Use 10% less energy than a minimally code-compliant baseline.”)
 - 1. Use energy performance goals in conjunction with schematic design information to determine how much (if any) improvement in baseline air leakage is needed as well as a compliance strategy to achieve it.
 - 2. Clearly state in initial specifications which method(s) of air leakage compliance will be used for the project and what target performance levels are to be achieved.

1.2 Design

- A. Establish line of communication between overall project architect/engineer and metal building supplier for coordination of details relevant to air barrier systems.
- B. Finalize envelope performance parameters as soon as they are established and communicate them to parallel design processes such as metal building supplier and foundation designer.
- C. Ensure the air barrier system components are clearly identified on project drawings.
- D. Ensure code compliance parameters relevant to the building envelope are shown on project drawings in the same format as other energy and life-safety compliance parameters.
- E. Specify penetration components such as roof hatches, smoke vents and pipe penetration boots specific to metal roofing and require that they be provided by the metal building supplier.
- F. Specify windows and personnel doors specific to MBS whenever possible.
- G. If storefronts are present, coordinate typical details with other project details, particularly for MBS.
- H. Ensure overhead doors components are tested for air barrier compliance and meet the assembly criteria provided.
- I. Ensure air barrier system components are clearly identified on MBS assembly drawings.
- J. Ensure details on MBS erection drawings are coordinated with the project drawings and specifications.
- K. Identify any areas where barriers are to be taped to metal framing and if necessary, provide metal building supplier surface cleaning and/or smoothness criteria.

1.3 Permitting/Bidding

- A. Select testing agency to perform whole-building test and provide contact information to selected General Contractor.

2.0 Pre-Construction Activities

2.1 Material Procurement and Fabrication

- A. Ensure air barrier system provider has complete and up-to-date MBS assembly drawings.
- B. Ensure compatibility of selected tapes and seals with insulation liners used in MBS assemblies.
- C. Determine appropriate facing tab(s) dimensions for selected system, keeping in mind depth of framing components as determined by MBS provider.
- D. If air barrier system components are to be taped to welded framing, take steps to clean and smooth weld splatter in connected areas, if needed.

2.2 Pre-Construction Meeting

1. Ensure testing agency is present at pre-construction meeting.
2. Clearly communicate responsibility for air barrier performance to each provider.
3. Provide guidance to each subcontractor on when testing should occur, and in which state the building is to be at test time.
4. Decide and communicate if MEP system installers are responsible for repair of air barrier system penetrations or if air barrier system installer is to repair penetrations. (Note: It is recommended that the air barrier system installer perform all repairs at one time.)
5. Ensure all MEP system installers have instructions for proper methods of CAB penetration.
6. If MEP system installers are to repair penetrations they make, the CAB system provider should ensure that they have the means and methods to do so.

3.0 Construction Activities

3.1 Envelope Installation

- A. Do not install cover trims for window and/or overhead door jambs, sills and headers until CAB is secured in place.
- B. Ensure landing trims, if used for interior wall corners and roof-to-wall interfaces, are in place prior to final placement of insulation.
- C. Ensure field conditions (i.e., temperature, relative humidity, etc.) at time of tape and seal application meet manufacturer requirements.
- D. Install CAB system components, addressing window, door and structural attachments or penetrations along the way.
- E. Perform a general visual inspection of the CAB system.
 1. Ensure all gaskets, seal and sweeps for overhead doors are in place and functioning properly.
 2. Utilize open and closed-cell foam to fill voids around doors and windows.
 3. Repair CAB system where visual inspection criteria is not met.

3.2 MEP/Structural Material CAB Penetrations

- A. Ensure proper trim is in place around duct openings and utilize open cell foam or mineral wool packing to fill voids.
- B. Repair CAB penetrations in accordance with instructions from air barrier system installer or mark/ note penetrations to be repaired by CAB system provider prior to testing.

3.3 Whole-Building Testing

- A. Ensure CAB repair materials are on-hand and accessible on test day.
- B. Ensure people trained in CAB repairs are available or on-call to take questions and assist in repairs.
- C. Prepare report indicating leaks discovered and recommend repairs.
- D. Disseminate report to all contractors touching CAB materials.

3.4 Project Closeout

- A. Prepare and distribute visual inspection reports and completed checklists to owner and Authority Having Jurisdiction (AHJ), if required.
- B. Ensure owner has instructions or other guidance on maintenance and repair of CAB items.

Appendix B – Sectional and Rolling Overhead Doors

Authored by members of DASMA, Door & Access Systems Manufacturers Association



Introduction

This appendix provides recommended best practices to ensure sectional and rolling overhead doors are properly sealed prior to the start of a whole-building air leakage test. In most cases, these doors will be the largest moving component on the exterior of the building. If the perimeter seals are not adequately installed and maintained, it will affect the air leakage of the building.

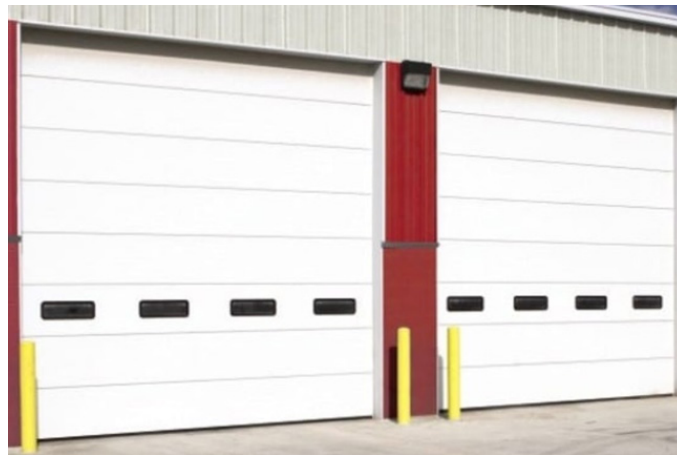


Figure B1: Sectional Doors



Figure B2: Rolling Doors

Door Type

For doors, the most fundamental element of air leakage performance is proper door selection. Insulated doors of both the sectional and rolling type present flush surfaces on the interior for weatherstrip to press against, whereas non-insulated versions of these doors often present large cavities on the interior that are difficult to seal.



Figure B3: Sectional Door, Insulated
– Interior View Shows Flush Surface



Figure B4: Sectional Door, Non-Insulated
– Interior View Shows Hollow Panels



Figure B5: Rolling Door, Insulated
– Interior View Shows Smooth Surface



Figure B6: Rolling Door, Non-Insulated
– Interior View Shows Slat Cavities

Air Leakage Rating

Recent versions of the International Energy Conservation Code (IECC) have component-level requirements for sectional, rolling, and high-performance doors. Many door manufacturers offer products with documented performance in compliance with these requirements. Look for an IECC label on the door or printed verification on the project's shop drawings.

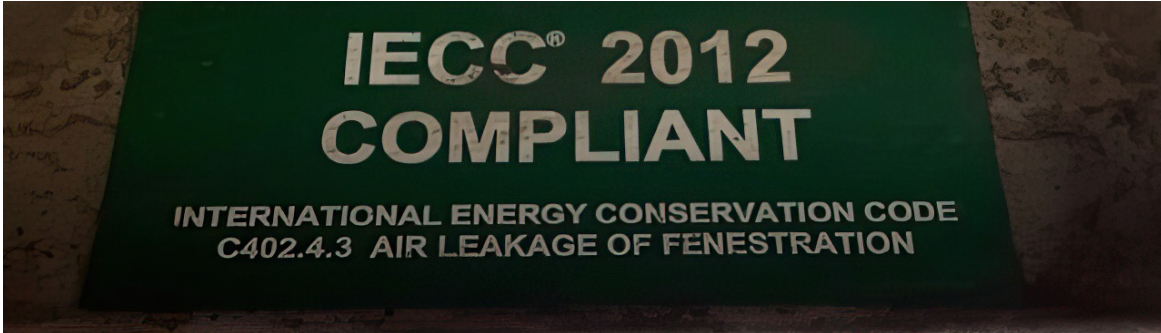


Figure B7: Label Indicating Air Leakage Testing

Proper Sealing Practices

Bottom Seal

The bottom of an overhead door usually includes an extruded astragal or sensing edge to seal the bottom edge of the opening.



Figure B8: Bottom Astragal



Figure B9: Sensing Edge

Bottom astragals and sensing edges should be in good condition and compressed firmly against the floor to close any gaps on floors that are not flat. However, take care not to over-compress, and thereby damage, sensing edges. For motorized doors, this gap is dependent on how the lower travel limit for the operator is set when the door is fully closed. A visual check should be made around the bottom sealing surface to ensure light is not coming through. The operator instructions should provide guidance on adjusting the lower travel limit.

Weatherstrip

Jamb and header seals are typically shipped and installed separately. Check the weatherstrip to ensure continuous contact between the weatherstrip and the door surface. Weatherstrip that has been torn, or that exhibits ripples or waves, will not provide an adequate seal. Any damaged or missing weatherstrip should be replaced.



Figure B10: Sectional Door Exterior Jamb and Header Seals – Good Condition



Figure B11: Rolling Door Exterior Guide Seals – Good Condition



Figure B12: High Performance Door Interior Guide Seals – Good Condition

Header Seal

The header seal should be examined closely to ensure it maintains firm contact across the full width of the opening. For wider rolling doors especially, curtain deflection may cause gaps toward midspan.



Figure B13: Rolling Door Exterior Jamb and Header Seal – Good Condition
(Also see Figure B10)

Joint Seal

Insulated sectional doors often include a seal within the section joint, which resists air leakage between sections. The seal can be observed when the door is part-way open, as the door transitions from a vertical to a horizontal position.

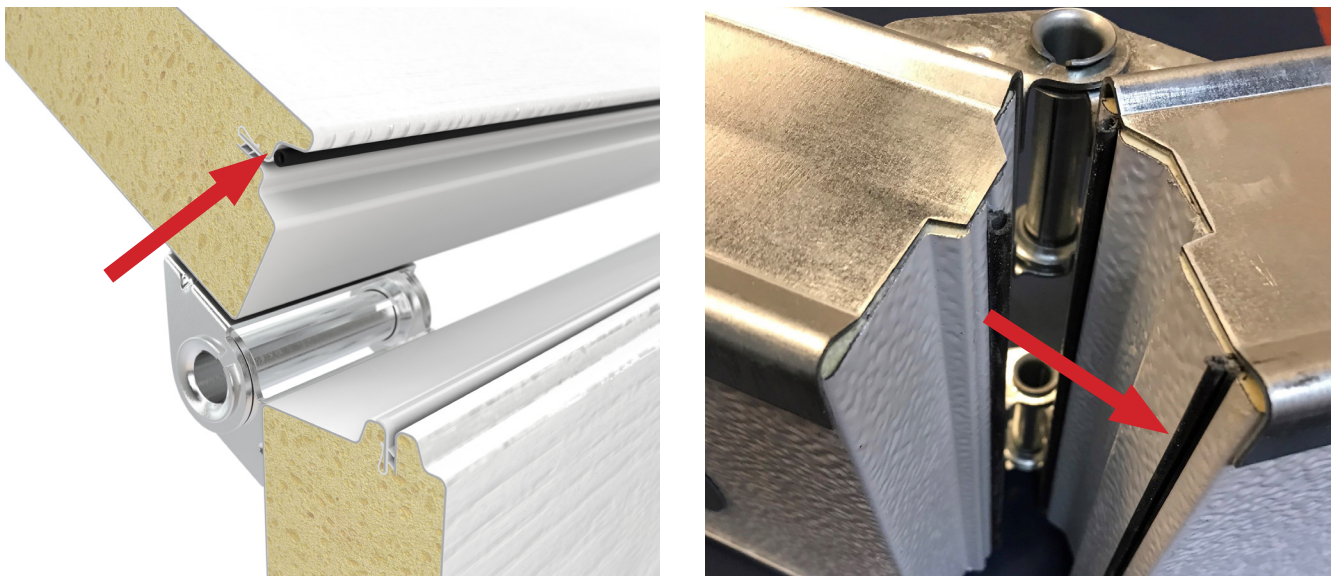


Figure B14: Sectional Door – Bulb Seal Between Sections

Top Fixture Adjustment

For sectional doors, the top rollers, both left and right, can be adjusted inward to press the top section more firmly against the jamb and header. Improperly adjusted top fixtures leave a gap for air leakage. Refer to manufacturer's installation instructions for guidance.



Figure B15: Sectional Door – Top Fixture

Windows, Louvers, and Vents

Sectional doors often include windows, which should be factory installed. There are also many types of louvers and vents that are occasionally installed in sectional doors for the purpose of ventilation. Visually inspect the windows, louvers, and vents, on both sides (exterior and interior), to verify a tight fit free of gaps or cracks.



Figure B16: Sectional Door – Windows



Figure B17: Sectional Door – Vent (a.k.a. Louver)

Work with Local Door Dealer

The above techniques are examples of the many ways attention to exterior doors can help to improve the performance of metal buildings during whole-building air leakage testing. The trained professionals in the door installation and service industry can assist with inspection and timely correction of any issues discovered.

Appendix C – Applicable Codes, Test Methods, and General Material Requirements

Introduction

Model national and local building codes have been very focused on reducing the energy used by building climate control systems for the last two decades. Insulation levels have gone up substantially during this time and are now at a point of diminishing returns. Focus has shifted to reduction of air leakage as a primary means to reach the ambitious energy efficiency and carbon reduction goals set by the federal and state governments as well as influential Non-Governmental Organizations (NGOs).

To better understand the air leakage performance of Metal Building Systems (MBS), the Metal Building Manufacturers Association (MBMA), the North American Insulation Manufacturers Association (NAIMA), and the Door & Access Systems Manufacturers Association (DASMA) undertook a multi-year air leakage study. MBS projects from around the country were tested for air leakage performance using the same techniques prescribed by the building codes administered by accredited third-party test agencies. As testing progressed, two things became very evident:

- When properly installed, MBS construction has an inherent ability to resist air leakage and generally exceeded initial expectations, often beating current code requirements by 20% or more.
- There is a tremendous potential for improvement beyond this initial baseline through relatively simple process adjustments and improved coordination.

As such, MBMA, NAIMA, and DASMA have developed these best practices.

Methods of Qualification

Current codes recognize three different approaches to qualify air barriers: 1) testing of individual components, 2) testing of assemblies, and 3) whole-building testing. Whole-building testing is the primary focus of this guide.

Whole-building testing is exactly as it sounds. The idea is to test the ability of the final, or very near final, building envelope to resist air movement. This is the most comprehensive way to determine air leakage, but it carries the primary disadvantages of timing difficulties between construction trades, potential access challenges if remediation is to be made, and nebulous accountability when the desired performance is not achieved. These can be serious practical issues.

Model Code Requirements

There are two primary model national energy codes in the United States, the International Energy Conservation Code (IECC), authored by the International Code Council (ICC), and the American Society of Heating, Refrigeration and Air Conditioning Engineers Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings* (ASHRAE 90.1).

Many states and municipalities have their own building energy efficiency codes which may be adoptions of one of the model national codes, a high-performance standard applied in addition to basic code requirements, or they may be entirely unique, as in the case of California Title 24.

When codes and standards implement air leakage requirements, they generally do so in the context of Continuous Air Barrier, or CAB provisions. When CABs are required, there will usually be dedicated passages in the code or standard covering the testing requirements as well as any required documentation of field activities to ensure CAB performance.

IECC

Prior to the 2021 edition, whole-building air leakage testing was not mandatory under the IECC. Instead, it was an alternative to the assembly and component requirements and was also recognized as an option for additional energy efficiency measures. The mandatory provisions only required one of these options to be executed, so CAB testing was generally passed over as it was viewed as too difficult to implement.

Starting with IECC 2021, whole-building testing is part of the mandatory CAB requirements but there are exceptions and allowances for conditions in which it may not be practical or effective.

The IECC 2021 criteria consists of two separate requirements, a “hard” limit of 0.6 cfm/ft² at 75 Pa, and a “soft” limit of 0.4 cfm/ft² at 75 Pa. If the hard limit is exceeded, a retest is required after remedial actions are taken. If the hard limit is met but the soft limit is not, a retest is not automatically required provided an evaluation utilizing leak indication is done and areas requiring repair are identified and repaired during pressurization/depressurization. These repairs must be documented in a report which is to be made available to the owner and the Authority Having Jurisdiction, or AHJ.

ASHRAE 90.1

Whole-building testing became mandatory in ASHRAE 90.1 starting with the 2019 version. The mandatory requirements are structured similarly to IECC 2021 but there are important differences. First, ASHRAE 90.1 recognizes semi-heated spaces, which are spaces without air conditioning and only a certain amount of heating capacity. Semi-heated spaces do not have to meet the CAB provisions in Climate Zones 0 to 6. However, ASHRAE does still require CABs for walls which separate conditioned and semi-heated spaces. Consequently, ASHRAE 90.1 is commonly invoked as an alternate compliance path when a building has semi-heated spaces.

The performance criteria for the whole-building test in ASHRAE 90.1 has hard and soft limits like those of IECC 2021 and the material and components requirements are similar as well.

High-Performance/Stretch Codes

Energy codes set minimum performance required for permitting, but that alone may not be sufficient. High-performance standards such as ASHRAE 189.1 add additional more stringent requirements beyond this level. They are usually voluntarily applied but some jurisdictions will adopt them or similar requirements as mandatory minimums. When done, these are often referred to as “Stretch Codes.”

Applicable Test Methods

ASTM E 779/E 1827/E 3158

ASTM E 779, E 1827 and E 3158 are the predominant whole-building test methods cited in the standards discussed here. ASTM E 779 and E 1827 are very similar but use different equipment designs for pressurization. The primary difference between these tests and E 3158 is that E 779 and E 1827 test the CAB of a single contiguous space at one time. ASTM E 3158 is intended to be used for large, multi-zone zone buildings where the entire envelope cannot be reliably tested at once. To the basic E 779/E 1827 process, E 3158 also adds provisions describing how the space is to be broken apart, how the test results for each space are to be combined and offers three different test procedures to provide maximum flexibility. When E 3158 is used, openings which are part of the mechanical system may be sealed (testing the exterior weather envelope) or unsealed (testing the operating envelope).

General Material Requirements

The CAB of MBS is generally not comprised of a single material such as a wrap. While building wraps may be used with MBS, they are not common and will not be addressed in this document.

Because the CAB is provided by many materials acting in unison, it is important to be able to identify which materials are critical to function prior to construction and material procurement. These materials are listed below with guidance to the installer regarding terminology and classification.

Metal Roof Panels

Metal roof panels are usually sealed to prevent liquid water intrusion for all but the steepest roof slopes. When sealed, they are the first line of defense against air infiltration, and they perform this function well. Consequently, significant air infiltration originating in the field areas of the roof is rare. However, discontinuities like high-low roof tie-ins, eave conditions and roof penetrations create situations where underlying materials become critical to performance. All best practices presented assume sealed roof panels and focus on discontinuities.

Metal Wall Panels

Metal wall panels may or may not be sealed at the side laps or ends. If not sealed, liquid water intrusion is controlled by flow velocity rather than sealants and closures. Unsealed panels still resist air flow to a large degree but ultimately, the insulation facings or liners become the primary CAB. Sealed wall panel systems function much like sealed roof panels in that significant air infiltration in the field areas is rare. The best practices presented reference both sealed and unsealed wall conditions. While both perform satisfactorily in air leakage testing, a mixture of sealed and unsealed conditions in the same wall plane is not recommended.

Fasteners

Whether a panel system is sealed or unsealed, any fastener exposed to the exterior should have a washer. In sealed wall systems, the fastener and washer are part of the CAB. Although no special treatment of fasteners is required in a sealed wall, the penetrations they make become more important to air barrier performance, so extra care should be taken to prevent dimpling caused by overdriving, skewed insertion or failing equipment.

Trim

Requirements given for sealed roof and wall panel systems generally apply to their trim components as well. Trim may also be used in the interior of the building to provide a landing surface for insulation facing tabs and CAB tape. When this is the case, the trim piece itself is part of the CAB assembly.

Insulation Facing

This document uses the term “facing” to describe CAB materials attached to insulation using a lamination process. Facings are not generally thought of as CAB materials in conventional construction, but they often perform that function in MBS, directly for unsealed panels and indirectly for sealed panel systems. Faced insulation may be compressed between the panel and framing member. This guide terms this an “outboard CAB.” Alternatively, the facing may be on an uncompressed interior insulation layer or even standalone. This guide uses “inboard CAB” to describe this system.

Inboard and outboard CABs present two very different scenarios when providing continuity. Outboard CAB wall systems will require continuity adjacent to the exterior flange of the framing. Continuity for inboard CAB systems is provided in the plane of the interior face of the framing. Both situations are addressed in this guide.

Insulation facings are typically wider than the fiberglass to which they attach. The portion of the facing extending past the fiberglass is called a tab. Tabs may or may not be symmetrical from side to side. They may also be present at one or both ends. There could be mixtures of different tab configurations as well, so it is important to separate these materials on site to avoid misplacement.

Liners

This document uses the term “liner” to describe CAB materials which are not attached to insulation. When used, liners are generally installed prior to insulation and in the case of roofs, provide a working surface upon which to place insulation. Some liners may even be part of a fall protection system. Generally, the same performance specifications apply to both liners and facings when used as the CAB. However, the installation methods are quite different.

Elastomeric Sealants

Elastomeric sealants are essential to good CAB performance. Fasteners commonly must pass through a sealant bead in MBS construction, and this often must be done blind. Therefore, it is critical to be consistent when placing sealants. Beads must be of the proper size and position. Too little sealant will not stop air or water, too much may prevent proper fit of attached materials, leading to poor performance as well.

Butyl sealants are widely used in MBS construction. They come in tape form as well as gun-grade tubes and sausages. They are high-solid, non-skinning sealants, which means they remain pliable for a very long time, giving them excellent resistance to expansion and contraction fatigue. However, they are susceptible to ultraviolet degradation and should not be exposed to sunlight.

Sealants exposed to sunlight are generally polyurethane, however, silicone is sometimes used in smoke and fire sensitive applications. Both polyurethanes and silicone sealants “skin,” pulling moisture from the air to chemically set from the outside to the inside. Consequently, time is of the essence when applying them.

Read and follow the instructions provided by the sealant manufacturer, paying close attention to the recommended application temperature and humidity limits. Store sealants in a temperature and humidity-controlled environment if site conditions warrant.

Foam Sealant

Expanding foam sealant is often used to fill large gaps conventional sealants cannot close. It readily adheres to most surfaces and is very useful when materials do not fit as expected. The foam expands to fill the void and if it should extrude out of the joint, it may be trimmed after fully curing. It is important for the installer to confirm that foam is compatible with the materials used. They are generally UV-sensitive and should not be exposed to sunlight, including through non-tinted windows.

Foam sealants come in both open and closed cell varieties and both perform well. Research has shown that open-cell foam thicknesses of 2 inches and greater is as effective in preventing air leakage as closed-cell foam of the same thickness.

Adhesive Tapes

Adhesive tapes are becoming increasingly popular to close gaps in CAB materials, particularly insulation facings and liners. Facings and liners come in a variety of materials, so it is key to read the manufacturer’s instructions to ensure compatibility. Consecutive runs of tape should always be lapped 2 to 3 inches. Small wrinkles in CAB tape are detrimental but not disastrous. If a tape run begins to drift off course as it is applied, it may be best to cut the tape and start a new run with a 3-to-4-inch back lap as opposed to pulling it off and re-setting. While tapes are excellent at closing CAB gaps, they are not a substitute for careful placement of CAB materials and should not be used to close gaps larger than one inch.

Best Practices to Comply With Whole-Building Air Leakage Testing Requirements For Metal Building Systems



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