

ANSI/AMCA Standard 540-23

Test Methods for Louvers Impacted by Wind Borne Debris

An American National Standard
Approved by ANSI on April 17, 2023



Air Movement and Control Association International

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Preface

ANSI/AMCA Standard 540-23 evaluates a louver's ability to remain unbreached by flying debris during a windstorm. This standard includes an optional test that evaluates a louver's ability to resist post-impact cyclic wind pressures. This standard also establishes the qualified sizes and configurations of a louver model that has undergone testing to this standard.

The duration of testing has no limit, meaning additional specimens may be tested at any time to qualify other configurations that previously were unqualified by this standard. This is limited to qualifications that can be tested with only one additional test specimen. A separate test report shall be prepared with applicable items from Section 12. However, alternate louver construction would require a complete set of test specimens per Section 5 following all the requirements of this standard. The following is a list of additional qualifications/revisions that are allowed and a list of revisions that are prohibited.

Allowed revisions:

- Shorter minimum blade spans
- Alternate mullion designs, including the mullion framing and connection of adjacent louver components to the mullion framing

Prohibited revisions:

- Changing from Basic Protection to Enhanced Protection
- Greater maximum unsupported blade span
- Alternate jamb frame profile, material and/or thickness
- Alternate head frame profile, material and/or thickness
- Alternate sill frame profile, material and/or thickness
- Alternate blade profile, material and/or thickness
- Alternate connection method between any components making up the louver assembly

Test Method for Louvers Impacted by Wind Borne Debris

1. Purpose

The purpose of this standard is to establish minimum performance requirements and uniform methods for laboratory testing of louvers that are impact tested with the “large missile” as defined in ASTM E1886.

2. Scope

This standard is to be used for impact testing of louvers that are installed on the outside of buildings and to assist in meeting the requirements of the International Code Council (ICC) International Building Code, the ICC International Residential Code and any other applicable codes or specifications.

The following precautionary statement pertains to sections 6 and 9 of this document: This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of the regulatory limitations prior to use.

3. References

The following documents contain provisions that, through specific reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.

2021 International Building Code, International Code Council, Country Club Hills, IL USA.

2021 International Residential Code for One and Two-Family Dwellings, International Code Council, Country Club Hills, IL USA.

AMCA Publication 512, *AMCA Listing Label Program*, Air Movement and Control Association International Inc., Arlington Heights, IL USA.

ASTM E1886-19, *Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials*, ASTM International, West Conshohocken, PA USA.

ASTM E1996-20, *Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes*, ASTM International, West Conshohocken, PA USA.

Test Application Standard (TAS) 203-94, *Criteria for Testing Products Subject to Cyclic Wind Pressure Loading*, Florida Building Code, Tallahassee, FL USA.

4. Definitions and Units of Measure

4.1 Definitions

For the purposes of this standard, the following definitions apply:

4.1.1 Enhanced Protection

An impact rating given to a louver by testing to Missile Level ‘E.’

4.1.2 Essential Facilities

See ASTM E1996, Section 6.2.1.1.

4.1.3 Basic Protection

An impact rating given to a louver by testing to Missile Level 'D.'

4.1.4 Horizontal blade louver

A louver with its exterior-most blades orientated horizontally.

4.1.5 Vertical blade louver

A louver with its exterior-most blades orientated vertically.

4.1.6 Specimen

A louver assembly for testing consisting of one or more louver sections.

4.1.7 Louver section

A single louver panel. Panels can (but are not required to) be connected to each other to make up larger assemblies for testing purposes. For example, a two-section wide louver assembly is two panels wide.

4.1.8 Mullion/section joint

A joint between two louver sections/panels.

4.1.9 Mullion

Consists of the frame and/or support members that are at/along each side of the mullion joint and are parallel to the joint.

Note: The most common mullion types are visible, recessed and architectural. See Figure 4.1.

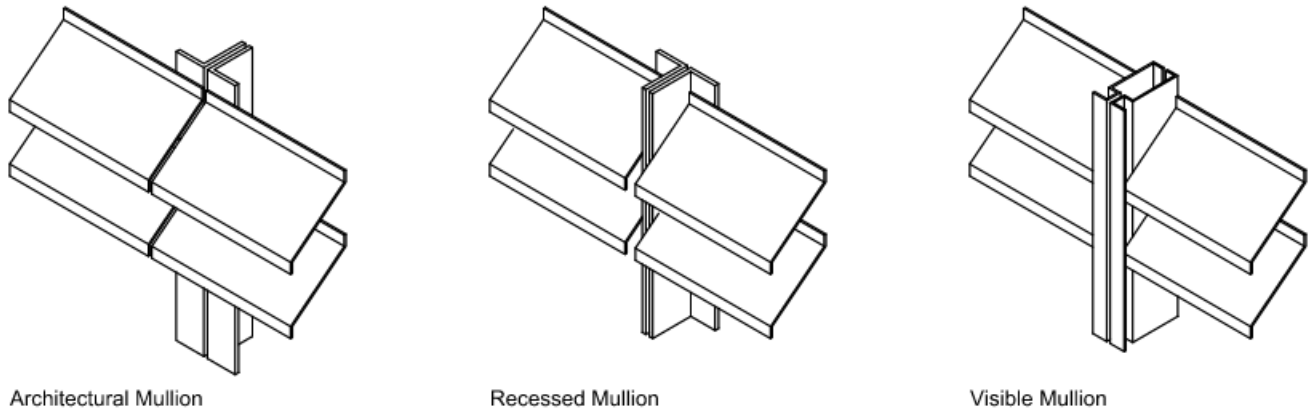


Figure 4.1 — Basic Mullion Types

4.1.10 Blade span

The distance from one end of the blade to the opposite end of the same blade. See Figure 4.2 for the extent of a blade span based on a typical (square cut) blade, a notched blade and a mitered blade.

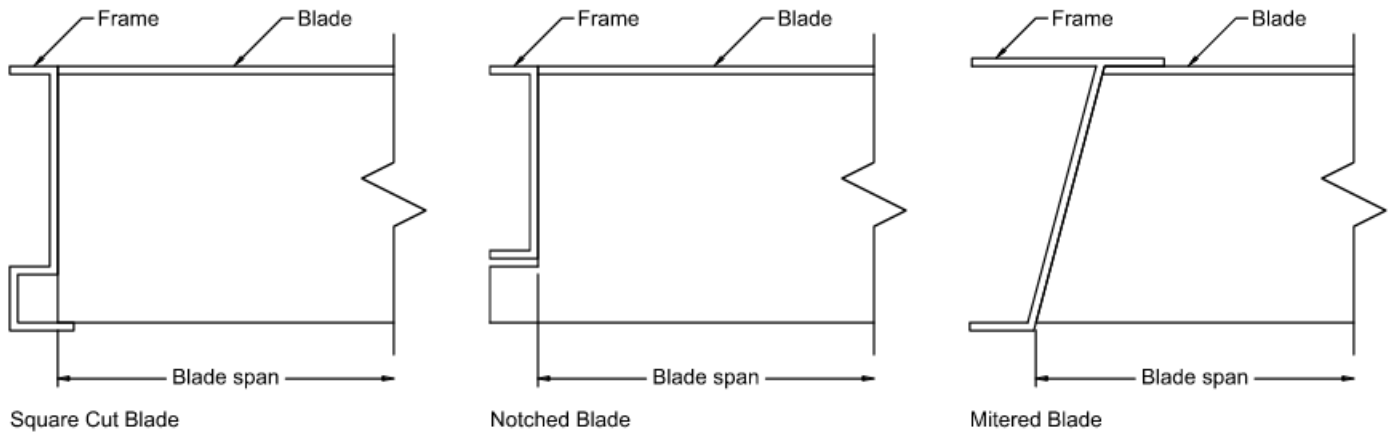


Figure 4.2 — Blade Span

4.1.11 Unsupported blade span

The distance from the blade end to the blade support or from blade support to blade support, which is equal to the blade span when no blade support is present. All measurements to a blade support are to the centerline of the blade support. The “blade end” noted herein is the same location on the end of the blade as is used for determining the blade span. See Figure 4.3.

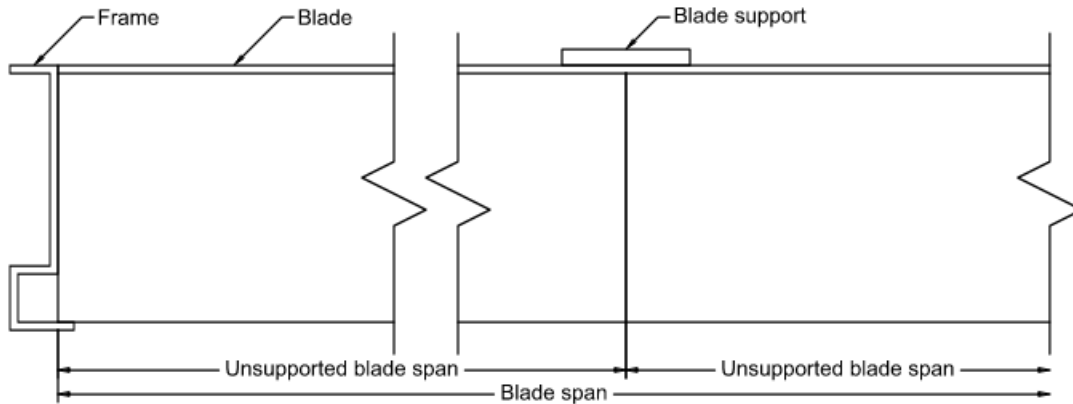


Figure 4.3 — Unsupported Blade Span

4.1.12 Frameless section joint

A joint between two louver sections in which blades run parallel to the section joint without additional louver frame members (that run parallel to the blades) present along the section joint. See figures 4.4 and 4.5.

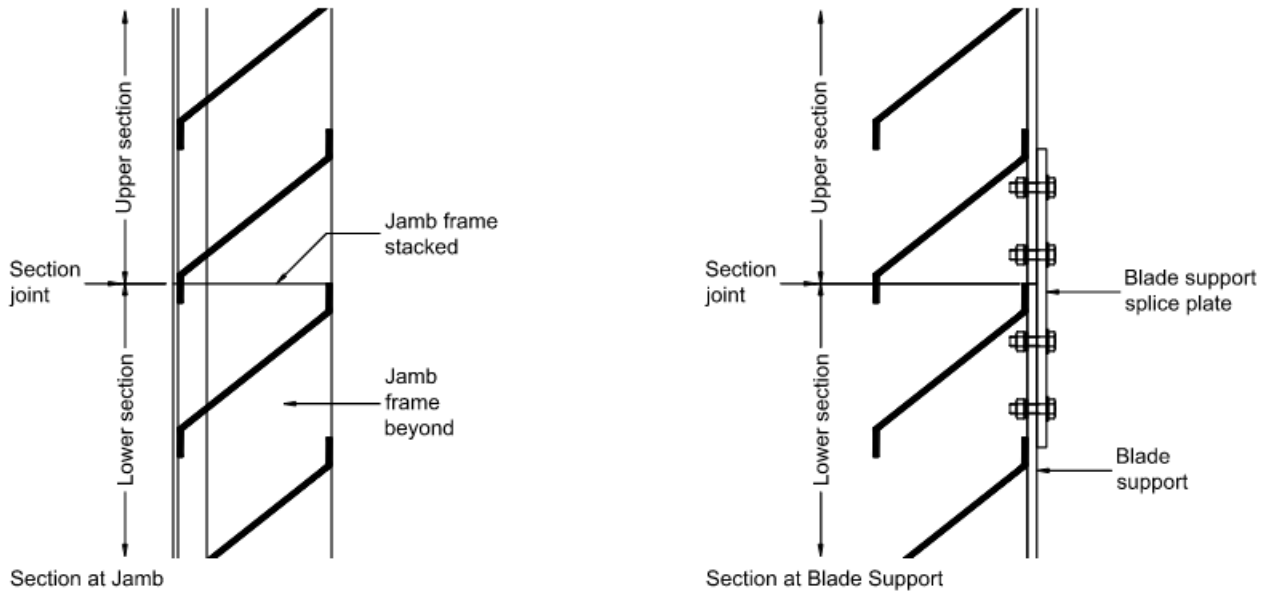


Figure 4.4 — Frameless Section Joint – Horizontal Blade Louver

Note:
Similar at head frame

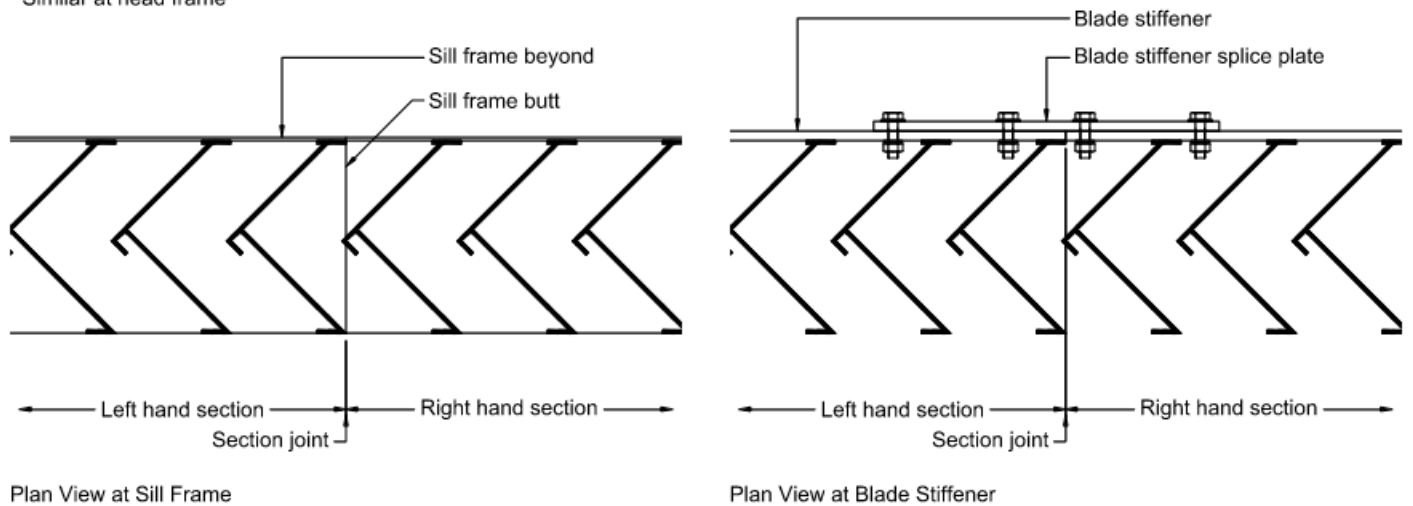


Figure 4.5 — Frameless Section Joint – Vertical Blade Louver

4.1.13 Dual-blade louver

A louver with more than one set of blades; each set of blades forms a front or rear assembly section. Blade sets can be orientated perpendicularly or at an angle to each other.

4.2 Units of measure

All units used in this standard are defined in ANSI/AMCA Standard 210. The primary units are The International System of Units, also known as Le Système International d’Unités (SI), with inch-pound (I-P) units given as the secondary reference.

5. Test Specimens

5.1 Number of specimens

5.1.1 Minimum number of sections

A minimum of three louver sections shall be impacted. This requirement shall be satisfied by testing one single-section and one multi-section specimen, three identical single-section specimens or one multi-section specimen that contains at least three sections.

Each unique mullion type shall require a minimum two-section specimen. Testing two different mullion types in a three-section specimen is allowed. Each louver section of a multi-section specimen shall count toward meeting the required number of sections.

An additional test specimen with a smaller unsupported blade span can be tested to qualify a different minimum blade span.

5.1.2 Additional specimen for impact failure retest

One additional specimen may be submitted for testing should any original submitted specimen described in Section 5.1 fail any impact portion of the ANSI/AMCA Standard 540 testing. This is described in Section 10.2.

5.1.3 Additional specimen for optional cyclic test

One additional specimen may be submitted to retest to the optional cyclic tests as long as the additional specimen first passes the ANSI/AMCA Standard 540 impact tests. This is described in Section 10.2.

5.2 Size of specimens

The test specimen selected is intended to evaluate the critical failure area of the louver and provide guidance for blade support requirements. The critical failure area for louvers is the connection between the louver blade end and the perimeter louver frame. Failures in this area result in loose material that can generate projectiles in high-wind events. The most stringent test specimen for this connection is a section in which the blade has no additional support between the jamb's end connections. The test specimen also provides guidance regarding the maximum unsupported blade length that will not allow the projectile to pass through the louver blades. Louvers manufactured with blade spans greater than that of the test specimen shall have their blades supported at a spacing not more than the blade span of the test specimen. These supports are typically located behind the blade running perpendicular to the blade's axis and are usually attached to the perimeter frame of the louver or to the surrounding building structure. An additional test specimen with a smaller unsupported blade span can be tested to qualify a different minimum blade span. The size of the test specimens shall be as defined in sections 5.2.1 and/or 5.2.2.

5.2.1 Single-section louver qualification

5.2.1.1 Horizontal blade

The test specimen shall consist of a single section with no blade support. The section width shall be equal to the maximum unsupported blade span plus the added width of the specimen jamb frames. The minimum height of the test specimen shall be 914 mm (36 in.). The test specimen shall also contain a minimum of five blades. See Figure 5.1.

The test specimen shall qualify single-section widths and blade spans greater than those of the specimen, provided the louver blades are supported at a spacing not more than the blade span of the test specimen. The tested width and blade span shall become the minimum section width and minimum blade span qualified by the impact test.

The test specimen shall qualify all single-section high as well as all single-section wide by multi-section high (stacked) assemblies that utilize a horizontal frameless section joint. All blade supports shall be either spliced between sections or supported by other structures at the section joint.

Note:

Missile shall impact the leading edge of the blade profile at all impact locations. See Figure 6.1 for detailed impact location.

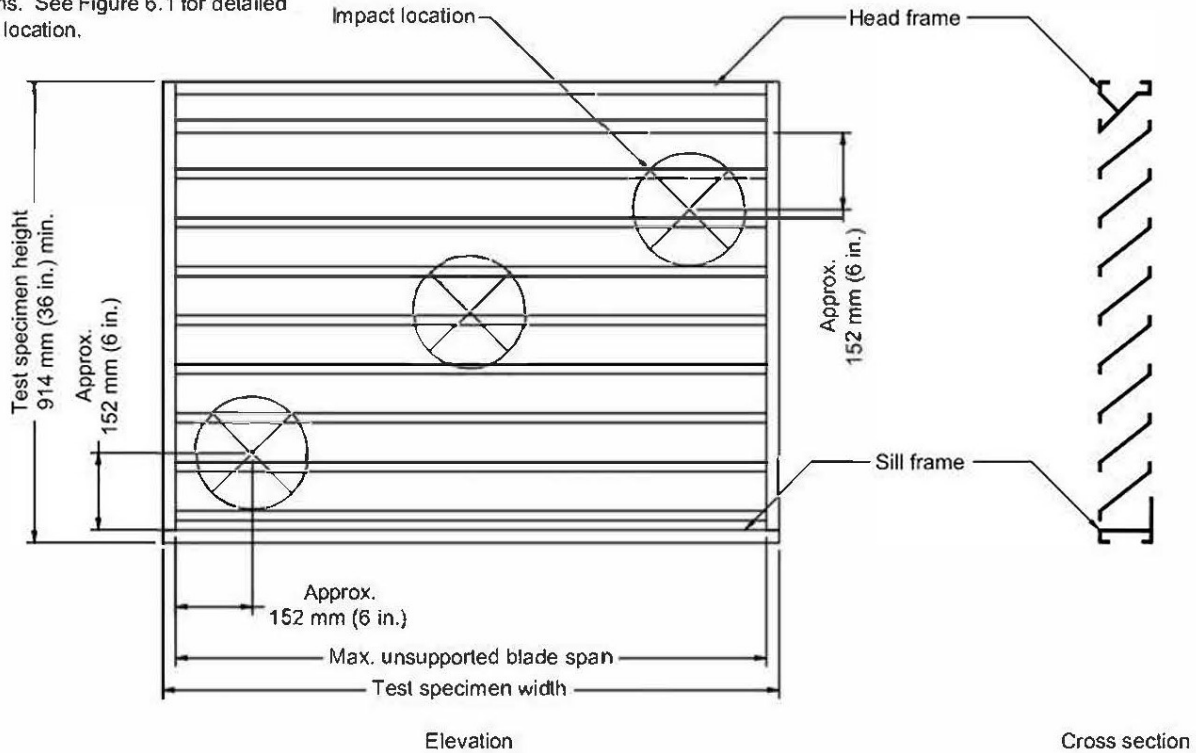


Figure 5.1 — Single-Section Test Specimen – Horizontal Blade Louver

5.2.1.1.a Minimum-qualified blade span

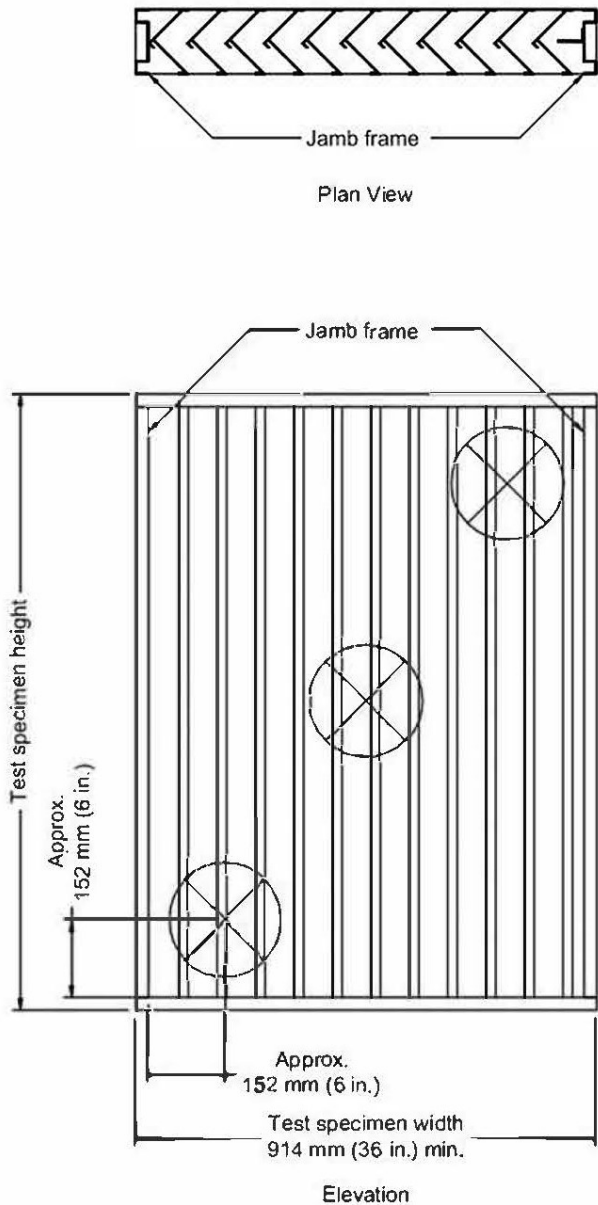
To qualify a blade span that is less than that of the test specimen in Section 5.2.1.1, an additional test specimen shall be provided. The minimum height of the test specimen shall be 914 mm (36 in.), and the test specimen shall contain a minimum of five blades.

5.2.1.2 Vertical blade

The test specimen shall consist of a single section with no blade support. The section height shall be equal to the maximum unsupported blade span plus the added thickness of the specimen head and sill frames. The minimum width of the test specimen shall be 914 mm (36 in.). The test specimen shall also contain a minimum of five blades. See Figure 5.2.

This test specimen shall qualify single sections of heights and blade spans greater than the specimen, provided the louver blades are supported at a spacing not more than the blade span of the test specimen. The tested height and blade span shall become the minimum section height and minimum blade span qualified by the impact test.

The test specimen shall qualify all single-section wide and all single-section high by multi-section wide (side-by-side) assemblies that utilize a frameless section joint. All blade supports shall be either spliced between sections or supported by other structures at the section joint.



Note:
Missile shall impact the leading edge of the blade profile at all impact locations. See Figure 6.1 for detailed impact location.

Figure 5.2 — Single-Section Test Specimen – Vertical Blade Louver

5.2.1.2.a Minimum qualified blade span

To qualify a blade span that is less than that of the test specimen in Section 5.2.1.2, an additional test specimen shall be provided. The minimum width of the test specimen shall be 914 mm (36 in.), and it shall contain a minimum of five blades.

5.2.2 Multi-section louver qualification

5.2.2.1 Multi-section horizontal blade

The test specimen shall consist of a minimum of two sections with no blade supports. Each section width shall be equal to the maximum unsupported blade span plus the added width of the section's frame members. Each vertical and/or horizontal mullion type seeking qualification to this standard shall be tested.

5.2.2.1.a Multi-wide horizontal blade with vertical mullion

The test specimen shall contain at least one vertical mullion, and more than one mullion type can be tested in a single test specimen. The test specimen shall be a minimum height of 914 mm (36 in.). Each section shall be the same height and contain a minimum of five blades. See Figure 5.3.

The height of the test specimen shall be equal to the maximum section height and maximum mullion span/height that is qualified by this standard. This test specimen shall qualify section widths and blade spans greater than the test specimen's section widths and blade spans, provided louver blades are supported at a spacing not more than the blade span of the test specimen.

Note:
Missile shall impact the leading edge of the blade profile at all impact locations. See Figure 6.1 for detailed impact location.

Note:
Additional framing or support at the mullion which are integral to the louver assembly is allowed.

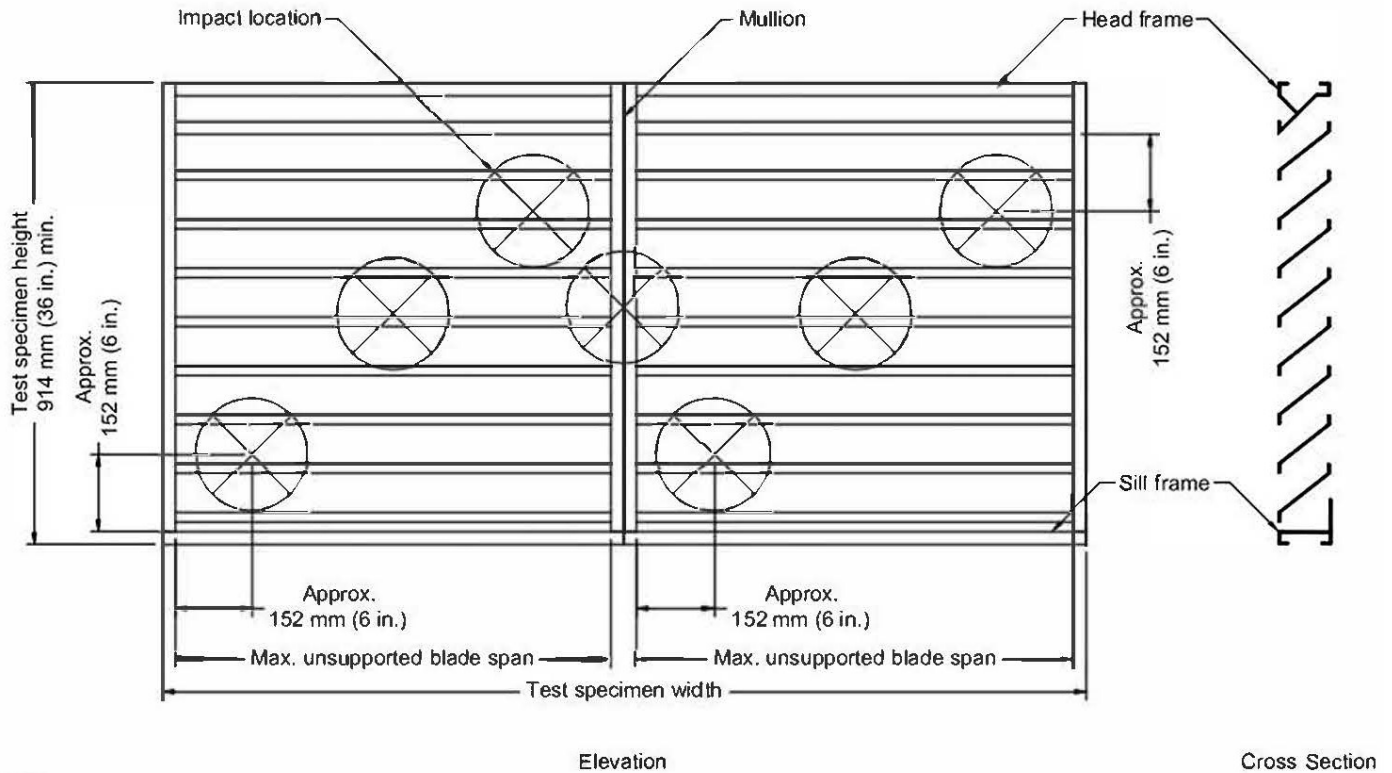


Figure 5.3 — Multi-Section Test Specimen – Horizontal Blade Louver with Vertical Mullion

5.2.2.1.b Multi-high horizontal blade with horizontal mullion

This section tests and qualifies multi-high horizontal blade assemblies that have a traditional head and sill or other frame member located at the horizontal mullion that does not conform to the allowable multi-high stacking qualifications of Section 5.2.1.1.

The test specimen shall contain at least one horizontal mullion, and more than one mullion type can be tested in a single test specimen. Each test section shall be a minimum height of 914 mm (36 in.), shall be the same width and shall contain a minimum of five blades. See Figure 5.4.

The test specimen shall qualify all section heights for both single-section and single-section wide by multi-section high assemblies. The test specimen shall qualify section widths and blade spans greater than the test specimen, provided the louver blades are supported at a spacing not more than the blade span of the test specimen.

Note:
Missile shall impact the leading edge of the blade profile at all impact locations. See Figure 6.1 for detailed impact location.

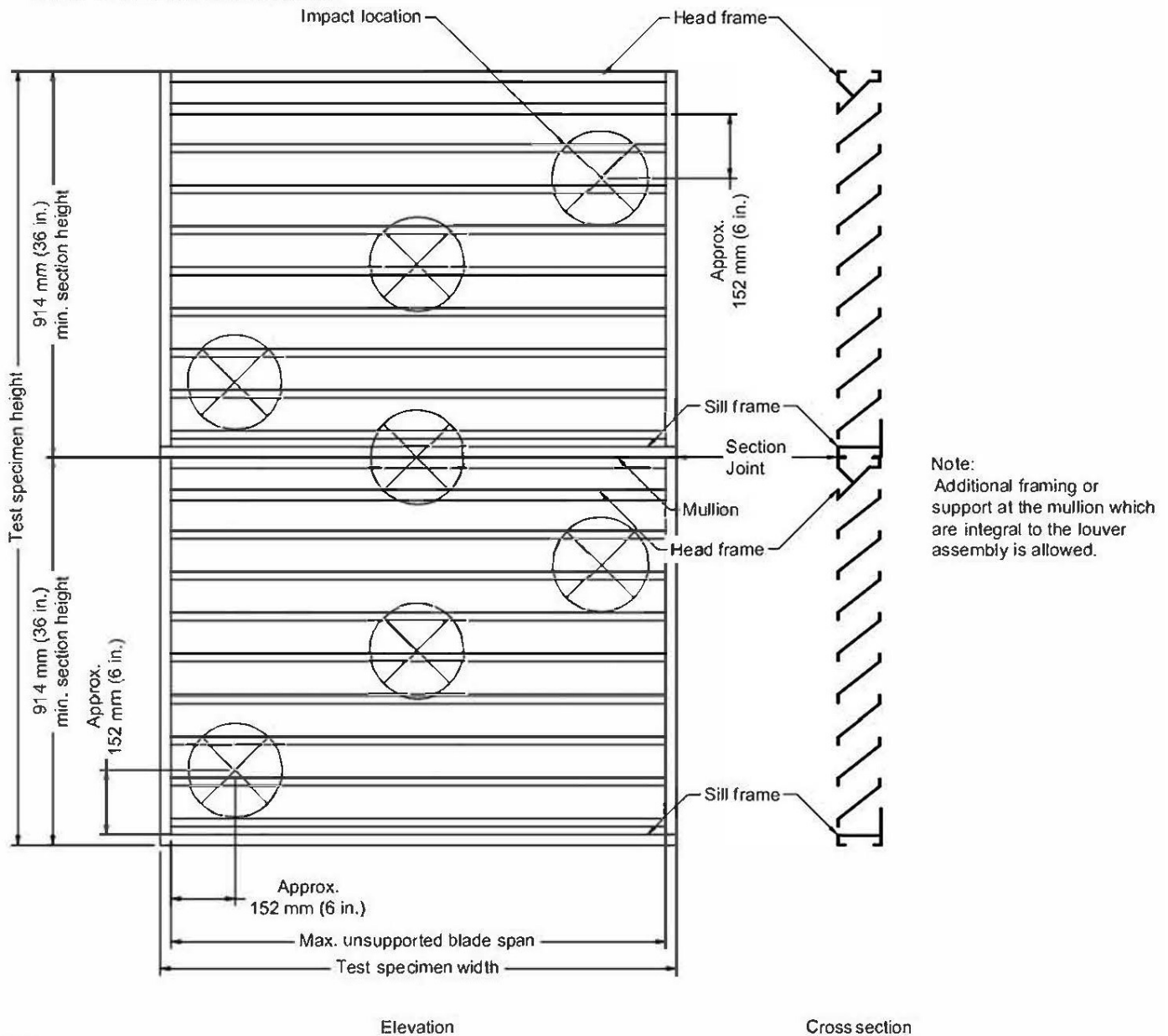


Figure 5.4 — Multi-Section Test Specimen – Horizontal Blade Louver with Horizontal Mullion

5.2.2.1.c Minimum qualified blade span

The multi-section minimum allowable blade span shall be based on one of the following tests:

- The smallest blade span multi-section tested sample
- The smallest blade span single-section tested sample

5.2.2.2 Multi-section vertical blade

The test specimen shall consist of a minimum of two sections with no blade supports. Each section height shall be equal to the maximum unsupported blade span plus the added thickness of the section's frame members. Each vertical and/or horizontal mullion type seeking qualification to this standard shall be tested.

5.2.2.2.a Multi-wide vertical blade with vertical mullion

This section is to test and qualify multi-wide vertical blade assemblies that have traditional jambs or other frame members located at the vertical mullion that does not conform to the allowable multi-section wide (side-by-side) qualifications of Section 5.2.1.2.

The test specimen shall contain at least one vertical mullion, and more than one mullion type can be tested in a single test specimen. Each test section shall be a minimum width of 914 mm (36 in.). Each section shall be the same height and contain a minimum of five blades. See Figure 5.5.

The test specimen shall qualify all section widths for both single-section and single-section high by multi-section wide assemblies. The test specimen shall qualify section heights and blade spans greater than the test specimen, provided the louver blades are supported at a spacing not greater than the blade span of the test specimen.

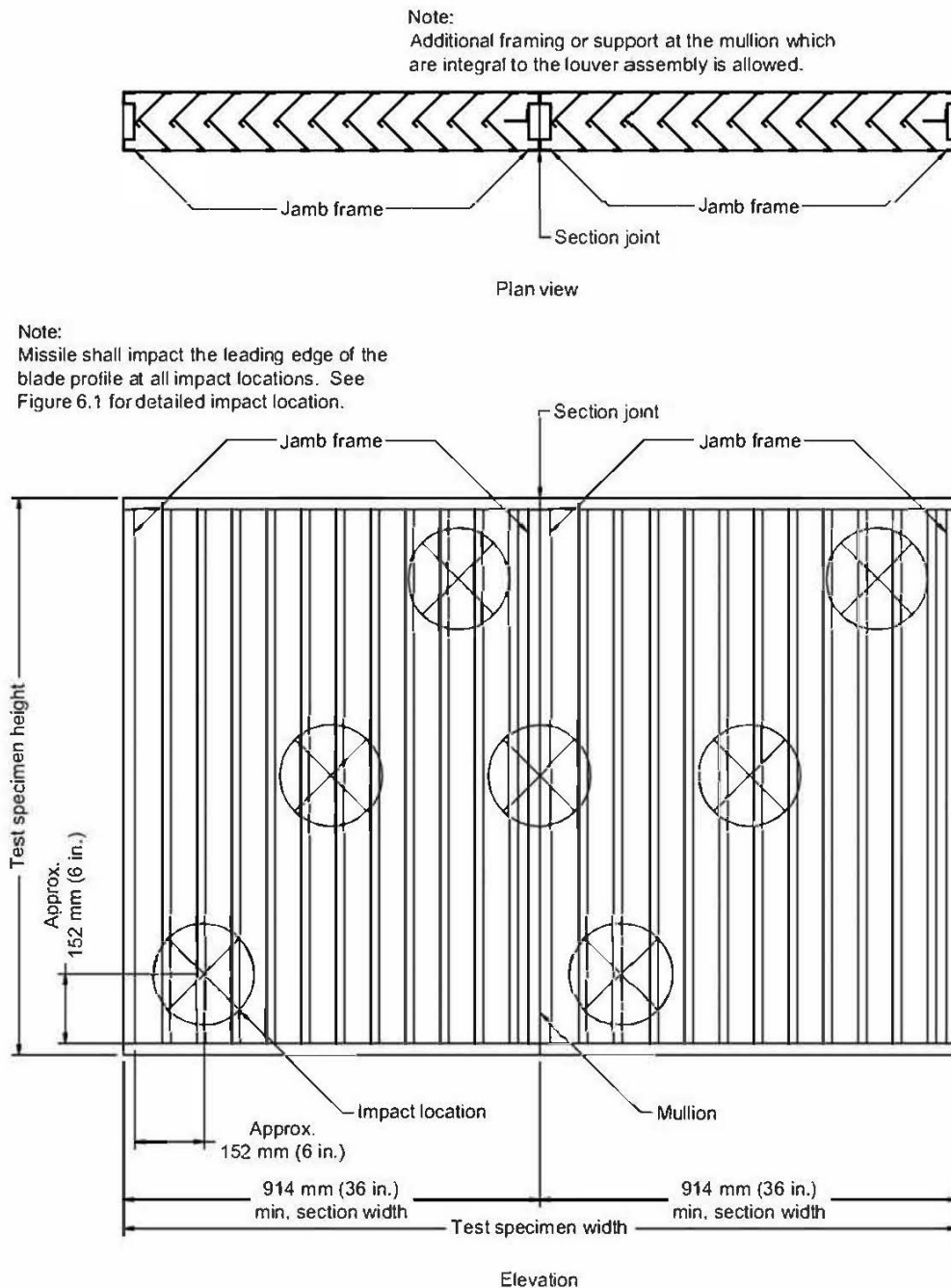


Figure 5.5 — Multi-Section Test Specimen – Vertical Blade Louver with Vertical Mullion

5.2.2.2.b Multi-high vertical blade with horizontal mullion

The test specimen shall contain at least one horizontal mullion, and more than one mullion type can be tested in a single test specimen. The test sections shall be a minimum width of 914 mm (36 in.). Each section shall be the same width and contain a minimum of five blades. See Figure 5.6.

The width of the test specimen shall be equal to the maximum section width and maximum mullion span/width that is qualified by this standard. This test specimen shall qualify section heights and blade spans greater than the test specimen's section heights and blade spans, provided louver blades are supported at a spacing not more than the blade span of the test specimen.

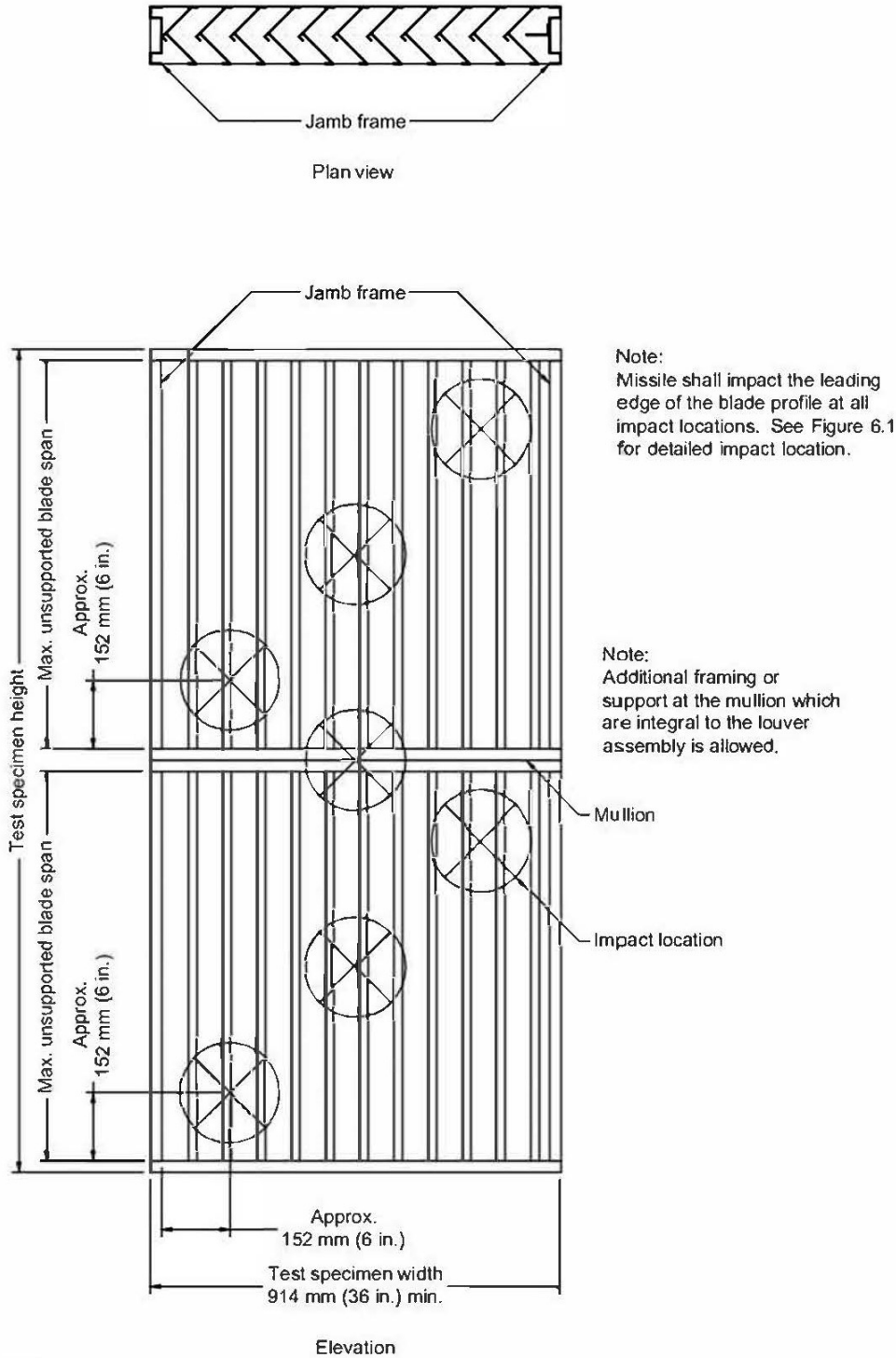


Figure 5.6 — Multi-Section Test Specimen – Vertical Blade Louver with Horizontal Mullion

5.2.2.2.c Minimum qualified blade span

The multi-section minimum allowable blade span shall be based on one of the following tests:

- The smallest blade span multi-section tested sample
- The smallest blade span single-section tested sample

5.3 Additional qualifications and requirements

Testing a multi-section louver shall also qualify a single-section louver to the same blade span as the tested multi-section louver, as long as outer perimeter frame members are the same as those on a single section, blade to outer perimeter connections are the same and perimeter corner construction/fastening are the same.

Each mullion type shall be tested, and the connection between the blade and mullion shall be allowed to be different than the connection between the jamb and outer perimeter frame.

When testing both single- and multi-section specimens, all specimens shall consist of the same outer perimeter frame members, have the same fastening method between the blade and outer perimeter frame member and have the same fastening method between matching outer perimeter frame corners.

5.4 Dual-blade louver

A dual-blade louver shall be designated and treated as a horizontal blade louver or a vertical blade louver based on the orientation of the blades on the front/exterior face of the louver. A blade support can be used on the rear set of blades only. The number of blades required for a test specimen shall be based only on the front/exterior set of blades.

6. Test Methods

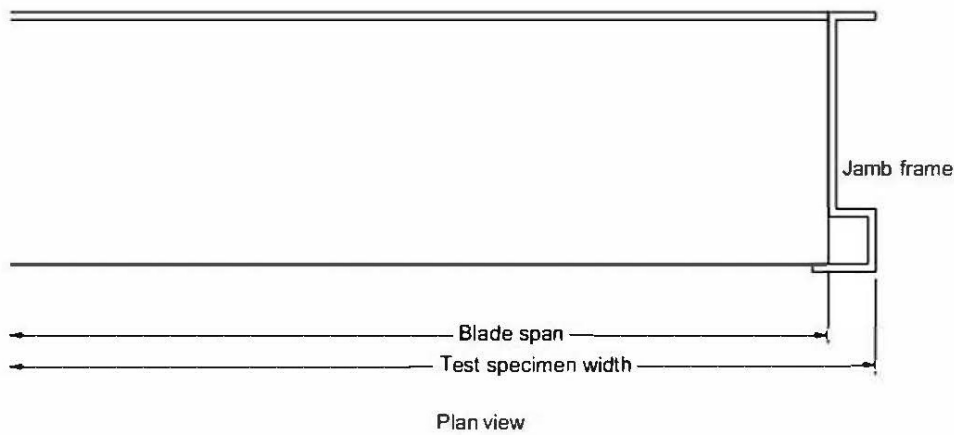
6.1 Specimens

Unless required differently by ANSI/AMCA Standard 540, the specimens and test methods shall comply with sections 3, 4, 6, 7, 9, 11 and 13 of ASTM E1886. Rotation of the test sample is permissible to overcome test laboratory width/height limitations.

6.2 Missile

The test requester shall be required to declare a missile classification from Table 1 for the louver prior to impact testing.

Natural rotation of a missile in flight is common. It shall be permitted to position the missile in the propulsion device so the missile has a higher chance of impacting the target location within tolerance. See Figure 6.1.



Note:
 Top right corner shown. Horizontal blades shown. Detail is similar at other impact locations and blade orientations.

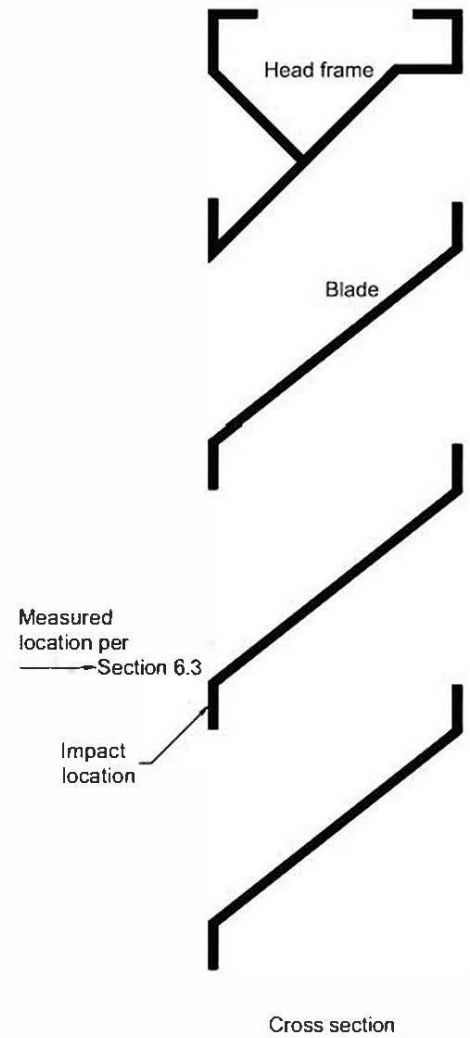
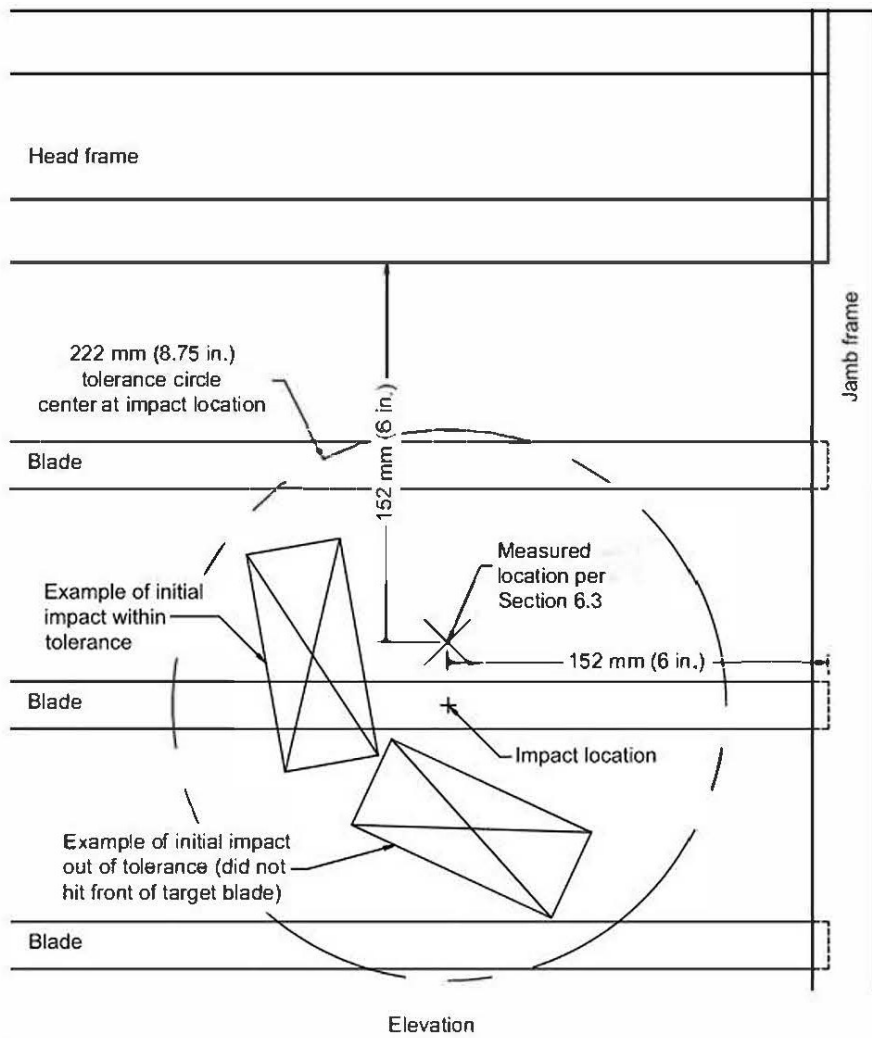


Figure 6.1 — Impact Location Tolerance

6.3 Locations of impact

6.3.1 Single-section impact locations

The initial contact between the missile and louver shall be in such a way that the entire leading face of the missile shall impact within a 222 mm (8.75 in.) diameter tolerance circle and any portion of the leading face of the missile shall impact the exterior-most edge or plane of the targeted blade.

The plane of the tolerance circle shall be on the same plane as the impacted face of the louver with the center of the circle at the targeted location as described in Section 6.3.1.1 or 6.3.1.2. See Figure 6.1. Once the leading face of the missile passes through the tolerance circle, it is permissible for the missile to make contact with the louver blades outside of the tolerance circle.

If the exterior most part of the targeted blade is a plane (vs. an edge), then the targeted location is adjusted after complying with Section 6.3.1.1 or 6.3.1.2 so that the targeted location is centered on the front plane of the blade. See Figure 6.1.

6.3.1.1 Horizontal blade impact locations

Impact each louver section three times as shown in Figure 5.1.

The first impact location shall be targeted on the front edge/surface of a blade closest to a point 152 mm (6 in.) from the plane of the cut end of the louver blade and 152 mm (6 in.) from the front interior edge of the sill.

The second impact location shall be targeted at the mid-span of a center blade on the front edge/surface of the blade. A center blade is one that is in the middle third of the louver's height.

The third impact location shall be targeted on the front edge/surface of a blade closest to a point 152 mm (6 in.) from the plane of the cut end of the louver blade and 152 mm (6 in.) from the front interior edge of the head. The third impact shall be adjacent to the jamb that is opposite of the jamb closest to the first impact.

6.3.1.2 Vertical blade impact locations

Impact each louver three times as shown in Figure 5.2.

The first impact location shall be targeted on the front edge/surface of a blade closest to a point 152 mm (6 in.) from the plane of the cut end of the louver blade and 152 mm (6 in.) from the front interior edge of the jamb.

The second impact location shall be targeted at the mid-span of a center blade on the front edge/surface of the blade. A center blade is one that is in the middle third of the louver's width.

The third impact location shall be targeted on the front edge/surface of a blade closest to a point 152 mm (6 in.) from the plane of the cut end of the louver blade and 152 mm (6 in.) from the front interior edge of the jamb. The third impact location shall be adjacent to the jamb that is opposite of the jamb closest to the first impact.

6.3.2 Multi-section impact locations

Each louver section shall be impacted in the same manner as a single-section louver of Section 6.3.1.

6.3.2.1 Visible mullions

The impact location shall be on the section joint and at the mid-span of the mullion. The 222 mm (8.75 in.) diameter tolerance circle is applied to the target location on a plane created by the exterior-most part of the mullion as shown in figures 5.3, 5.4, 5.5 and/or 5.6. Once the leading face of the missile passes through the tolerance circle, the missile is permitted to make contact with the louver mullion and/or blades outside of the tolerance circle.

The missile shall also impact the exterior face of the mullion.

6.3.2.2 Recessed or hidden mullions

The impact location shall be on the section joint and on the front edge/surface of the blade closest to the mid-span of the mullion. The 222 mm (8.75 in.) diameter tolerance circle is applied to the target location on a plane created by the exterior-most part of the louver blades similar to that shown in figures 5.3, 5.4, 5.5 and/or 5.6. Once the leading face of the

missile passes through the tolerance circle, the missile is permitted to make contact with the louver mullion and/or blades outside of the tolerance circle.

A missile is permitted to not make actual contact with the parts used to create a recessed or hidden mullion member.

6.4 Assembly mounting

Test specimens shall be rigidly mounted to the test frame using a continuous angle to support the louver assembly perimeter. A minimum 2.5 mm (0.10 in.) thick aluminum angle or minimum 16-gauge steel angle shall be deemed sufficient to meet this requirement. Continuous angles shall be allowed to stop short of a section/panel corner by no more than 203 mm (8 in.). This maximum distance shall also apply to the continuous angle stopping short of any mullion/support mounting hardware. The continuous angle shall not protrude past the interior edge of the frame by more than 25 mm (1 in.).

This standard does not evaluate or qualify:

- the fastening methods or fasteners used to attach the louver assembly to the test frame,
- the test wall,
- the test frame,
- the continuous angle used to mount the test specimen during the test

6.5 Sequence of impacts

Following the exact sequence of impact locations during testing is not necessary, which helps facilitate ease of testing, such as by minimizing cannon repositioning and setup.

6.6 Out of tolerance impacts

It is permissible to impact a louver location in a different yet similar location if the missile was out of tolerance.

A different yet similar location is defined as follows:

- The target offset distance from the end of the blade must be maintained.
- For a horizontal blade louver, the location of a re-impact is offset up/down from the original impact by several blades.
- For a vertical blade louver, the location of a re-impact is offset left/right from the original impact by several blades.
- The re-impact's tolerance circle shall be located on blades that have not been damaged by previous impacts unless the test requestor gives prior approval.
- For mullion impacts, the center of the re-impact tolerance circle shall be located along the length of the mullion that is not more than 305 mm (12 in.) from the center of the initial tolerance circle's location.

Alternately, an identical additional test specimen can be impact tested. The only required impact(s) on the additional test specimen shall be the out-of-tolerance impact location(s). However, if the primary test specimen was to undergo cyclic pressure testing per Section 9, then the additional test specimen shall be impact tested to all the required impact locations per Section 6.3 and pass per Section 8. The additional test specimen shall be cyclic pressure tested instead of the primary test specimen.

6.7 Missile removal

Once the missile has come to rest after impacting the louver, additional damage and/or alteration to the test specimen due to the missile's removal by laboratory personnel shall be disregarded when determining the pass/fail status of the impact. If a blade end breaks free from the perimeter frame during the above removal and the test specimen is to undergo cyclic pressure testing per Section 9, then the test specimen shall be impacted again (and pass) in a similar yet different location (see Section 6.6) for that impact location to be evaluated properly to the cyclic pressure test criteria.

6.8 Short blade spans

The center of the impact target location on blade spans of less than 305 mm (12 in.) shall be at the blade's mid-span.

7. Missiles

The missile used shall be that as described in Table 1.

7.1 Building-type requirements

Unless specified otherwise, when a building code or other specification requires a louver to be impact protected, the level of required protection shall be as noted per sections 7.1.1 and 7.1.2.

7.1.1 Enhanced Protection

Enhanced Protection (Missile Level 'E') shall be required for louvers on buildings and other structures designated as Essential Facilities (see Section 4).

7.1.2 Basic Protection

Basic Protection (Missile Level 'D') shall be required for louvers on any other buildings or structures that are not Essential Facilities.

8. Pass/Fail Criteria

An impact shall be rated as "Pass" only if compliance to all of Section 8 is demonstrated; otherwise, the impact shall be rated as "Fail." See Section 10.2 for additional testing allowances of a failed impact test.

8.1 Missile penetration

The missile shall not penetrate beyond the blade material (or mullion material for mullion impacts) except fragments as defined in Section 8.1.1.

8.1.1 Missile fragments

Following impact, individual missile fragments that penetrate beyond the louver shall not exceed 5% of the original missile weight.

8.2 Louver components

Louver components shall remain attached to adjacent parts or components. Adjacent parts or components are defined as attached (even if the blade end connection is loosened) as long as the component is connected to the adjacent part or component by a fastener and/or part of a weld. Each end of the blade-to-frame connection shall comply with Section 8.2.

A blade end may become loose from the frame member if a fastener becomes loose, is partially pulled out, is partially pulled through and/or has its head broken off, etc. However, the blade end shall still be considered connected if a part of the fastener is confined by the hole it originally went through.

Fastener heads or parts of fasteners/welds that become separate from the test specimen shall not constitute an impact or cyclic failure, provided the other requirements of Section 8.2 are met.

8.3 Cylinder test

Upon completion of the missile impact(s) and after removal of the missile, a cylinder, 76 mm (3 in.) in diameter and oriented perpendicular to the front plane of the louver, shall not pass through the impact location or other areas affected by the impact.

9. Optional Cyclic Pressure Test

9.1 Procedure

A building code or other specification may require a louver to pass additional cyclic pressure testing based on a building's location, building type and/or location of the louver on the building. Section 9 contains the requirements of an optional cyclic pressure test that is performed following ANSI/AMCA Standard 540 impact testing. Impact testing shall be conducted in accordance with this standard. Louvers shall be cyclic pressure tested to the requirements of sections 2

through 3.9, 6.3 through 8.1 and 12 of Test Application Standard (TAS) 203, Criteria for Testing Products Subject to Cyclic Wind Pressure Loading. The specimen sizes, installation and anchorage requirements are outlined in Section 9.2.

The test requester shall be required to declare a design pressure for the louver prior to cyclic pressure testing.

9.2 Test specimens

A minimum of three louver sections shall be cyclic pressure tested following ANSI/AMCA 540 impact testing. Any combination of single- and/or multi-section louver specimens shall be permitted. Each louver section shall contain the longest unsupported blade span that is to be qualified to Section 9. Each mullion type intended to be qualified to Section 9 shall be tested. The optional shorter/minimum blade span test specimen shall not be cyclic pressure tested, and a shorter blade section/panel shall not be within a multi-section test assembly that will be cyclic tested.

One additional specimen may be submitted for testing should an originally submitted specimen fail any portion of the ANSI/AMCA Standard 540 testing. This is described in sections 9.3.1 and 10.2.

Following the requirements of Section 6.4, it shall be permissible to repair any damage to the test frame mounting anchorage prior to cyclic testing.

This standard does not evaluate or qualify the fastening methods or fasteners used to attach the louver assembly to the test frame, the test wall, the test frame itself or the continuous mounting angle used during the test.

9.3 Pass/Fail criteria

A cyclic test shall be rated as "Pass" only if the cyclic test specimen demonstrates post-cyclic compliance to sections 8.2 and 8.3 and each test specimen demonstrates compliance to Section 6.5 of TAS 203 (i.e., 90% recovery over maximum deflection without resultant failure or distress). If the cyclic test specimen cannot demonstrate compliance, it shall be rated as "Fail." Resultant failure or distress shall be defined by sections 8.2 and 8.3. See Section 9.3.1 for additional testing allowances of a failed cyclic test.

9.3.1 Additional cyclic retest specimen

Of all the required cyclic test specimens, only one additional identical specimen complying with Section 10.2.1 may be submitted for cyclic retesting as long as the additional specimen first receives all impacts per Section 6.3 and passes all impacts per Section 8.

10. Product Qualification

10.1 Passing test specimen

When the test specimens have met the impact test requirements of Section 8, the set of test specimens shall be qualified as having an impact rating of Enhanced Protection (Missile Level 'E') and/or Basic Protection (Missile Level 'D') based on the tested missile type.

When the test specimens have met the cyclic test requirements of Section 9, the set of cyclic test specimens shall be qualified as having a cyclic pressure rating equal to the tested cyclic design load.

10.2 Failed test specimen

If a test specimen fails to meet the passing requirements of Section 8, it shall be rejected. Only one additional-impact test specimen that complies with either Section 10.2.1, 10.2.2 or 10.2.3 shall be allowed to replace the failed test specimen. The additional test specimen shall pass per Section 8 for it to be impact rated and included in the set of test specimens of Section 10.1. Any further impact failure of the additional test specimen shall constitute failure of the entire set of impact test specimens and impact product qualification shall be rejected.

If a cyclic impact test specimen fails to meet the passing requirements of Section 9.3, it shall be rejected. Only one additional cyclic test specimen that complies with Section 9.3.1 shall be allowed to replace the failed test specimen. The additional test specimen shall pass per Section 9.3 for it to be cyclic rated and included in the set of test specimens in Section 10.1. Any cyclic failure of the additional test specimen shall constitute failure of the entire set of cyclic test specimens and, cyclic product qualification shall be rejected. Failure to comply with the cyclic testing (or retesting) of this standard shall not void any testing and/or qualification the louver has regarding impact testing and/or qualification.

10.2.1 Entire specimen replacement

One identical replacement of the entire test specimen is allowed. The replacement test specimen shall be subject to all the required testing of the original test specimen, and all pass/fail results of the original failed test specimen shall be ignored. This option includes both single-section and multi-section specimens.

10.2.2 Section/panel only replacement

An identical replacement of one or more sections/panels on a multi-section test specimen is allowed. Replacement test sections shall be inserted into the original test assembly to replace any failed sections. All replaced sections shall be impacted at the three required impact locations, but a non-failed original section shall only be required to be impacted at any location where it has not yet been impacted.

10.2.3 Failed mullion impact

If a specimen fails a mullion impact, a replacement test specimen shall include at minimum the sections on both sides of the failed mullion. All replaced sections shall be impacted at the three required impact locations, a non-failed original section shall only be required to be impacted at any location where it has not yet been impacted.

10.3 Automatic qualification

A qualification to the Enhanced Protection speed automatically includes qualification to the Basic Protection speed without additional testing.

10.4 Enhanced Protection requirement

For test specimens to be rated to the Enhanced Protection level of impact resistance, all required impacts shall pass when tested to the Enhanced Protection (Missile Level 'E') criteria.

10.5 Minimum blade span qualification

The shorter/minimum blade span test section/panel shall be impacted three times in the same manner as the longest unsupported blade span test section. The test specimen shall pass per Section 8 for it to be included in the set of impact test specimens of Section 10.1. Section 6.6 shall still apply to the shorter blade span test specimen(s).

10.5.1 Testing of the shorter blade span

Due to the possibility that several shorter/minimum blade span test specimens, with various blade spans, may be required to determine the minimum length of the short blade span that produces a passing test specimen, any failure of a shorter blade span test specimen shall be ignored when determining the louver's maximum unsupported blade span qualifications.

If a shorter blade span test specimen fails any of the three impacts, a complete replacement test specimen of any blade span can replace the failed test specimen and the results of the failed test specimen shall be ignored. This cycle of re-testing for a shorter blade span has no limit.

The shorter blade span test specimen of Section 10.5.1 shall not have the same blade span as the longest unsupported blade span test specimen(s).

11. Limitations

11.1 Maximum section/panel size of a multi-section

The maximum section/panel height of a horizontal blade multi-wide section assembly that is qualified to ANSI/AMCA Standard 540 shall be equal to the overall section height that was tested.

The maximum section/panel width of a vertical blade multi-high section assembly that is qualified to ANSI/AMCA Standard 540 shall be equal to the overall section width that was tested.

11.2 Smallest section/panel size

The smallest section/panel width of a horizontal blade louver that is qualified to ANSI/AMCA Standard 540 shall be equal to the overall section width of the shortest blade span test specimen.

The smallest section/panel height of a vertical blade louver that is qualified to ANSI/AMCA Standard 540 shall be equal to the overall section height of the shortest blade span test specimen.

11.2.1 Exception

Exception: If a horizontal/vertical blade span of 305 mm (12 in.) or less is qualified, all shorter blade spans shall also be qualified.

11.3 Shaped louvers

Shaped louvers shall be qualified, provided blade-to-frame and frame-to-frame fastening method(s), and material of construction are the same as the tested configuration(s). If the construction is different, then the shape, or its non-shaped counterpart, shall be fully tested to this standard. Construction includes methods of attachment (for both frame-to-frame and blade-to-frame), material thickness and component material grades, alloys and tempers.

The minimum blade span and maximum unsupported blade span of shaped louvers shall not be different from that of a qualified non-shaped counterpart. See Section 11.2 for minimum blade length.

12. Report

A test report shall be submitted in its entirety and shall include, at minimum, the following:

1. Date of test, date of report and a unique identification number. The identification number shall be printed on each page
2. The name(s) of the author(s) of the report
3. A record of the:
 - a. Name and location of the facility performing the test and the name and address of the requester of the test
 - b. Names of the individuals performing the test and any witnesses
4. Consecutive page numbers with an indication of the total number of pages
5. The test standard designation, including the date of issue, and an explanation detailing any deviation from the standard
6. The test report shall be signed and sealed by a registered Professional Engineer employed or contracted by the testing laboratory
7. A description of the louver, including:
 - a. Manufacturer's model number or any other method of identification
 - b. Any louver drawings and photographs
 - c. A detailed description of the installation method (including fasteners)
 - d. Whether there is a damper or operable blade louver (if so, the position of operable blades shall be listed as fully open or fully closed)
 - e. Any other items. Include detailed dimensions and descriptions
 - f. If used, a description of the component used to keep operable blades fully open or closed
8. Detailed drawings of the test specimen, showing dimensioned section profiles (including blade spacing), blade-to-frame connection details, frame-to-frame connection details (corners), fasteners and any other pertinent construction details
9. Any deviation from the drawings or any modifications made to the test specimen to obtain the reported values shall be noted on the drawings and in the report

Note: Items 10-12 on the manufacturer-supplied drawing should be checked against the test specimen. Unverifiable items from this list must be documented in the report.
10. Full sample:
 - a. Louver overall width
 - b. Louver overall height
 - c. Louver depth
 - d. Blade spacing
 - e. Number of blades

11. For head frame, jamb frame, sill, blades and other components, verify:
 - a. Material (aluminum components are aluminum, steel components are steel, etc.; checking chemical composition is not necessary)
 - b. Width of component
 - c. Depth of component
 - d. Thickness of component (check two locations on the component)
 - e. Features and shape of component visually matches drawing
12. For connection details, verify:
 - a. Blade-to-frame connections
 - b. Sill-to-jamb connections
 - c. Head-to-jamb connections (verification shall consist of visually inspecting weld sizes and lengths and inspecting fastener diameters and lengths)
 - d. Other connections shown on manufacturer's drawings
13. Calibration data and calculations (a calibration record of all instruments used shall be reported)
14. For each missile impact, provide the following:
 - a. Description of missile(s) including dimensions and mass (weight)
 - b. Missile speed and data recorded to determine speed
 - c. Impact location and description of any damage of each impact
 - d. Pass/fail statement for each impact
15. A statement that the tests were conducted in accordance with ANSI/AMCA Standard 540 and received a pass/fail grade and Basic or Enhanced Protection
16. A statement that the laboratory is in possession of a video recording of the test. The video recording shall be retained by the laboratory for a minimum period of five years from the test report date
17. Signature of persons responsible for test supervision
18. For louvers tested to the cyclic pressure testing of Section 9, provide the following:
 - a. The maximum deflection recorded and the mechanism used to make such determination
 - b. Any permanent deformation (provide a cross-section diagram to show where it occurred)
 - c. The test report signed and sealed by a registered Professional Engineer employed or contracted by the testing laboratory
 - d. A tabulation of the pressure differences exerted across the specimen during the test and their duration
 - e. The maximum positive and negative pressures used in the test
 - f. A description of the condition of the test specimens after testing, including details of any damage and any other pertinent observations
 - g. A statement as to whether or not tape or film, or both, were used to seal against air leakage and whether, in the judgment of the test engineer, the tape and/or film influenced the results of the test
19. All data not required herein but useful to a better understanding of the test results, conclusions or recommendations appended to the report

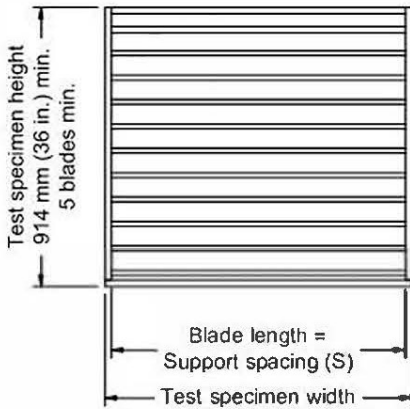
Table 1 — Missiles

Missile Level	Protection Level	Missile	Impact Speed
D	Basic	4100 g ± 100 g (9.0 lb ± 0.25 lb) 2x4 in. 2.4 m ± 100 mm (8 ft ± 4 in.) lumber	15.25 m/s (50 ft/s) ± 2%
E	Enhanced	4100 g ± 100 g (9.0 lb ± 0.25 lb) 2x4 in. 2.4 m ± 100 mm (8 ft ± 4 in.) lumber	24.38 m/s (80 ft/s) ± 1%

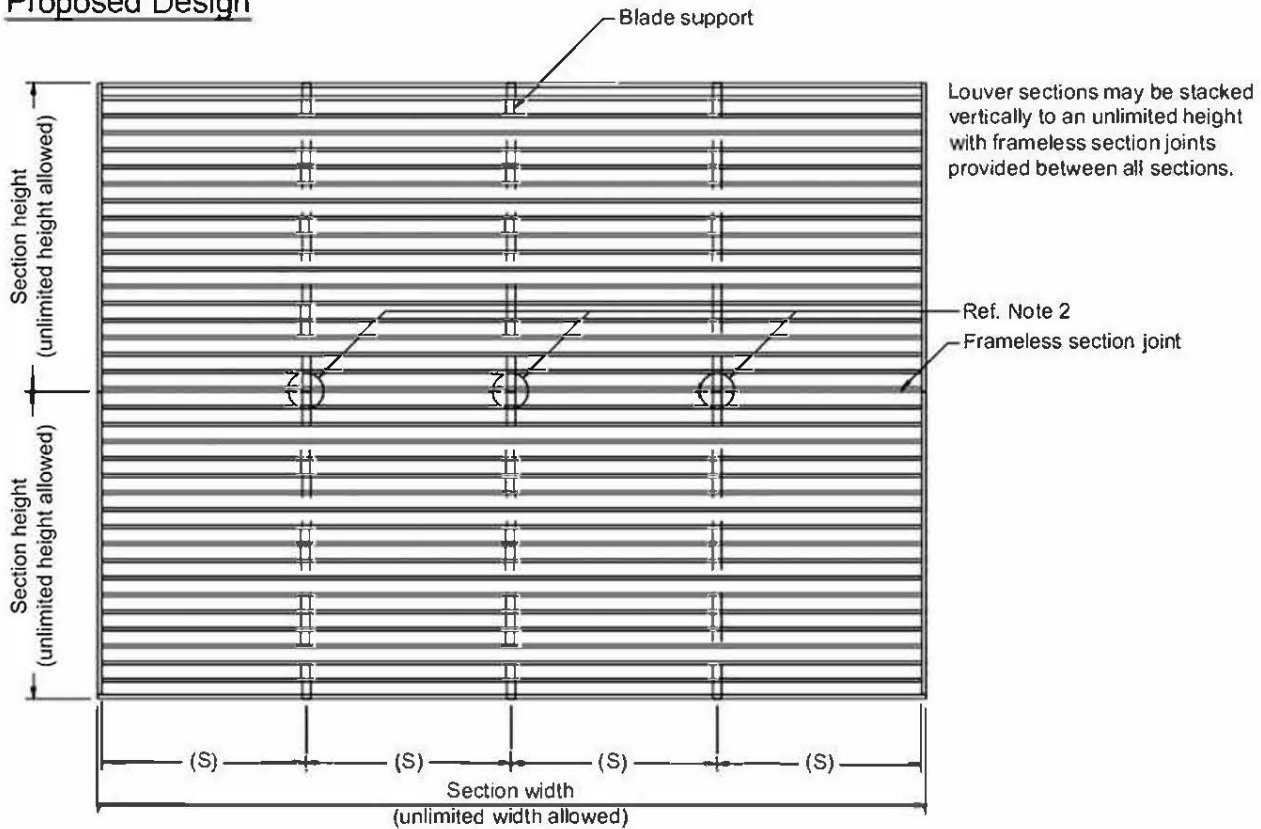
Annex A

Test Specimen Reference Figures (Informative)

Test Specimen



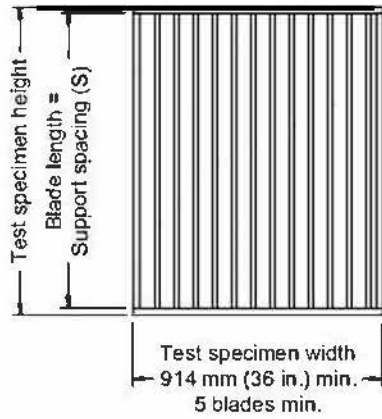
Proposed Design



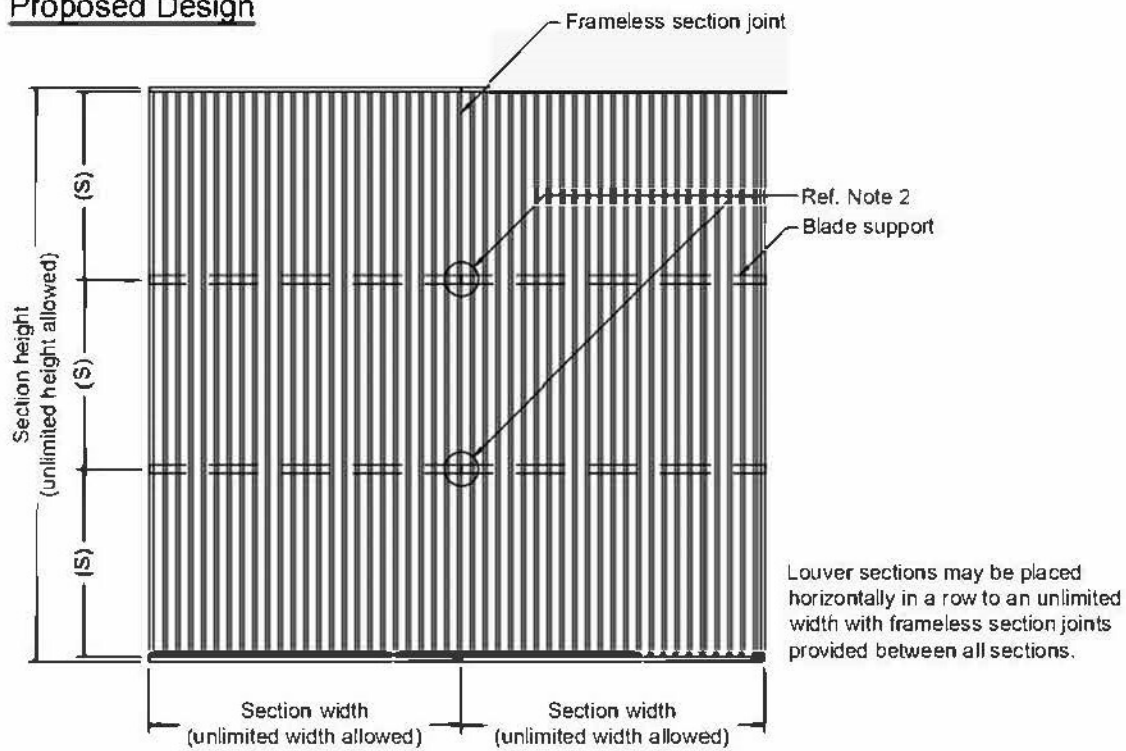
1. Qualification of blade lengths smaller than the test specimen blade length requires an additional test. See Section 5.1.1.
2. When stacking multiple horizontal blade sections vertically, blade supports shall be moment spliced at the frameless section joint or supported by other structures.

Figure A.1 — Example of Single-Section Wide by Multi-Section High with Frameless Section Joint, Horizontal Blade Louver Qualification

Test Specimen



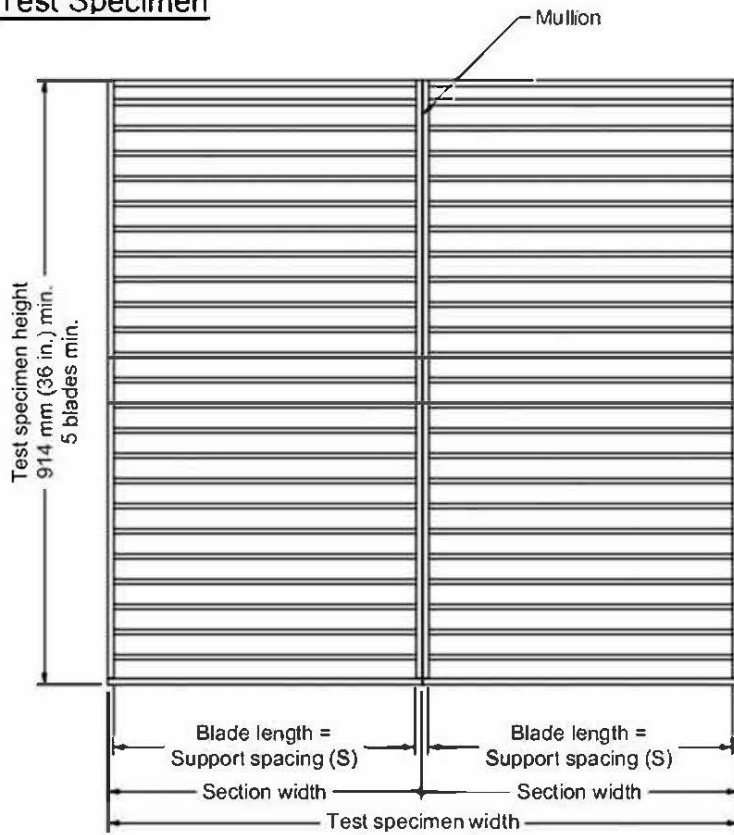
Proposed Design



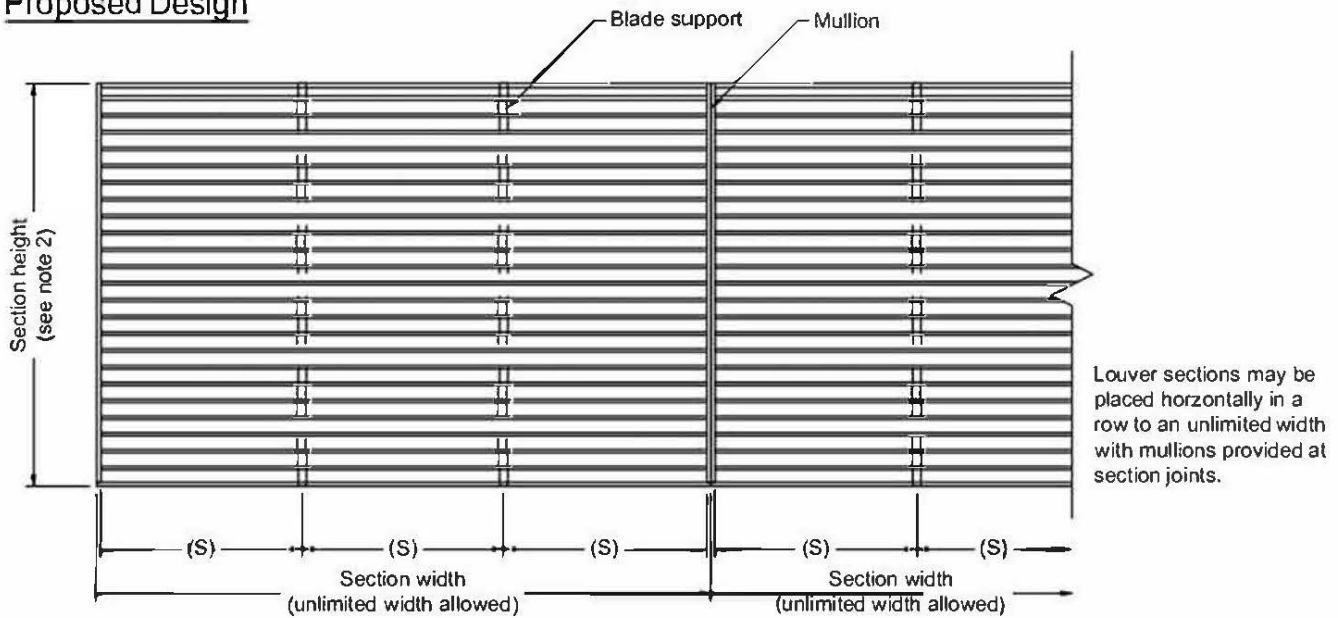
1. Qualification of blade lengths smaller than the test specimen blade length requires an additional test. See Section 5.1.1.
2. When placing multiple vertical blade sections horizontally, blade supports shall be moment spliced at the frameless section joint or supported by other structures.

Figure A.2 — Example of Single-Section High by Multi-Section Wide with Frameless Section Joint, Vertical Blade Louver Qualification

Test Specimen



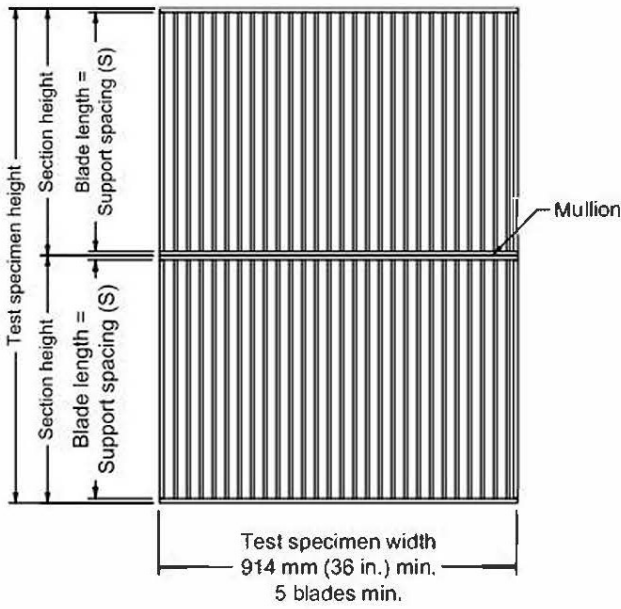
Proposed Design



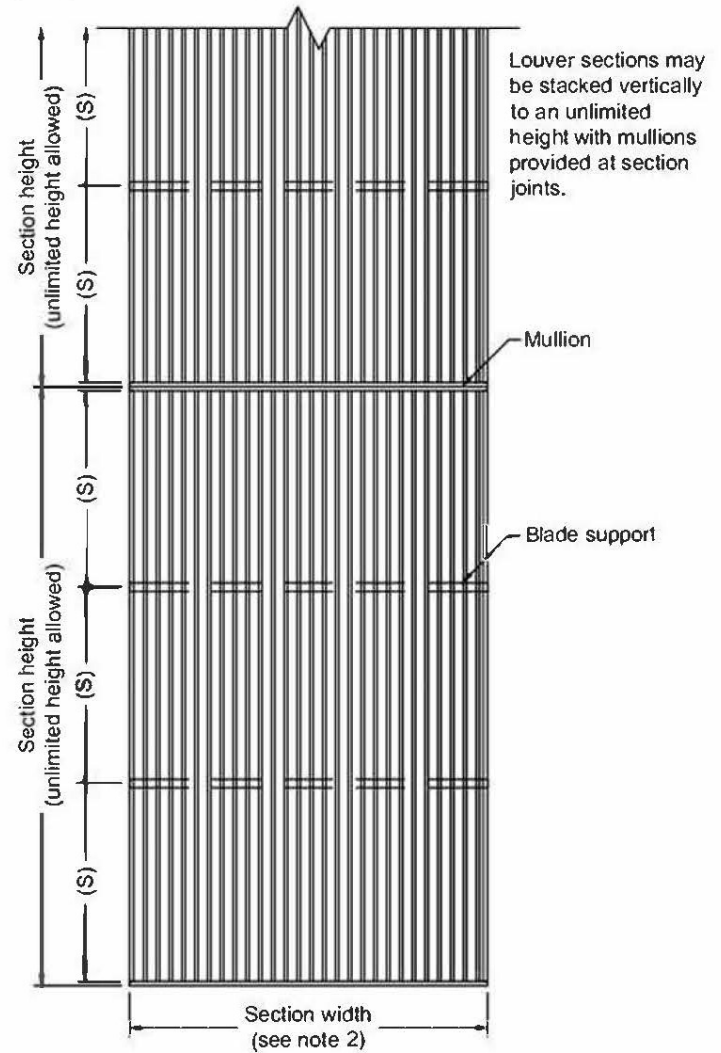
- 1- Qualification of blade lengths smaller than the test specimen blade length requires an additional test. See Section 5.1.1.
- 2- Maximum qualified section height is equal to the test specimen height.
- 3- Two sections shown for qualification of one mullion type. Three or more sections may be tested to allow qualification of multiple mullion types with one test specimen. For example, when qualifying an architectural, recessed, and visible mullion types with a single test specimen.

Figure A.3 — Example of Multi-Section, Horizontal Blade Louver with Vertical Mullion Qualification

Test Specimen



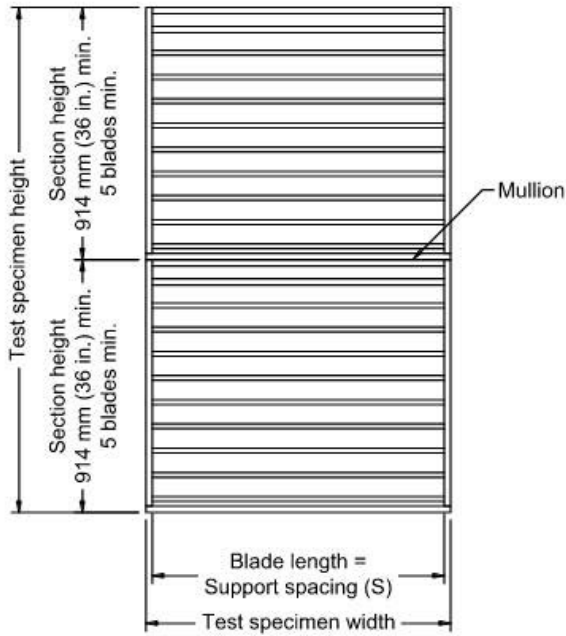
Proposed Design



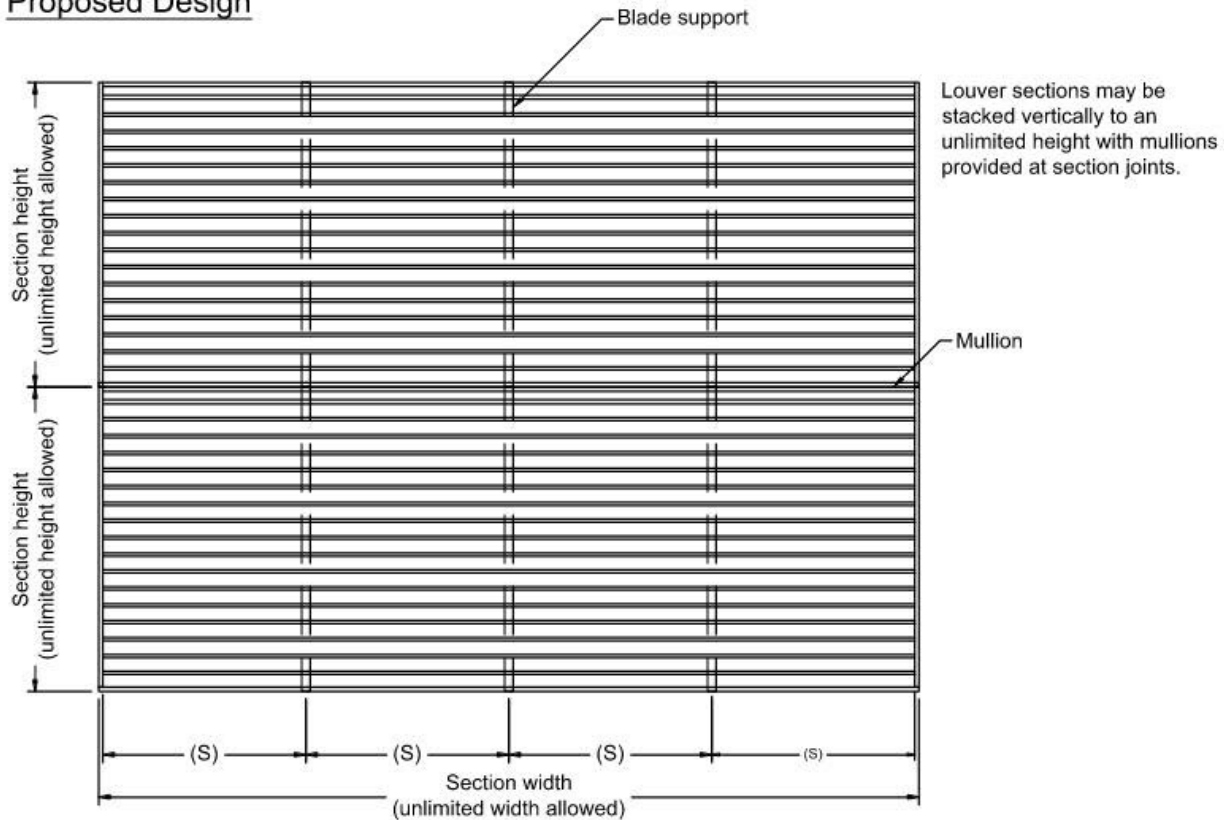
1. Qualification of blade lengths smaller than the test specimen blade length requires an additional test. See Section 5.1.1.
2. Maximum qualified section width is equal to the test specimen width.
3. Two sections shown for qualification of one mullion type. Three or more sections may be tested to allow qualification of multiple mullion types with one test specimen. For example, when qualifying an architectural, recessed, and visible mullion types with a single test specimen.

Figure A.4 — Example of Multi-Section, Vertical Blade Louver with Horizontal Mullion Qualification

Test Specimen



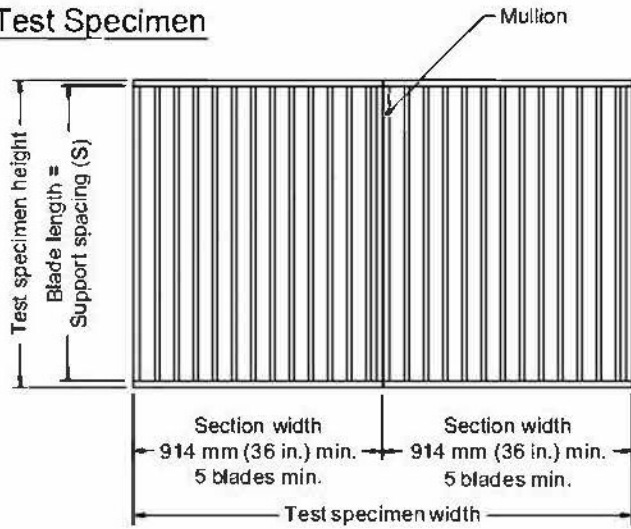
Proposed Design



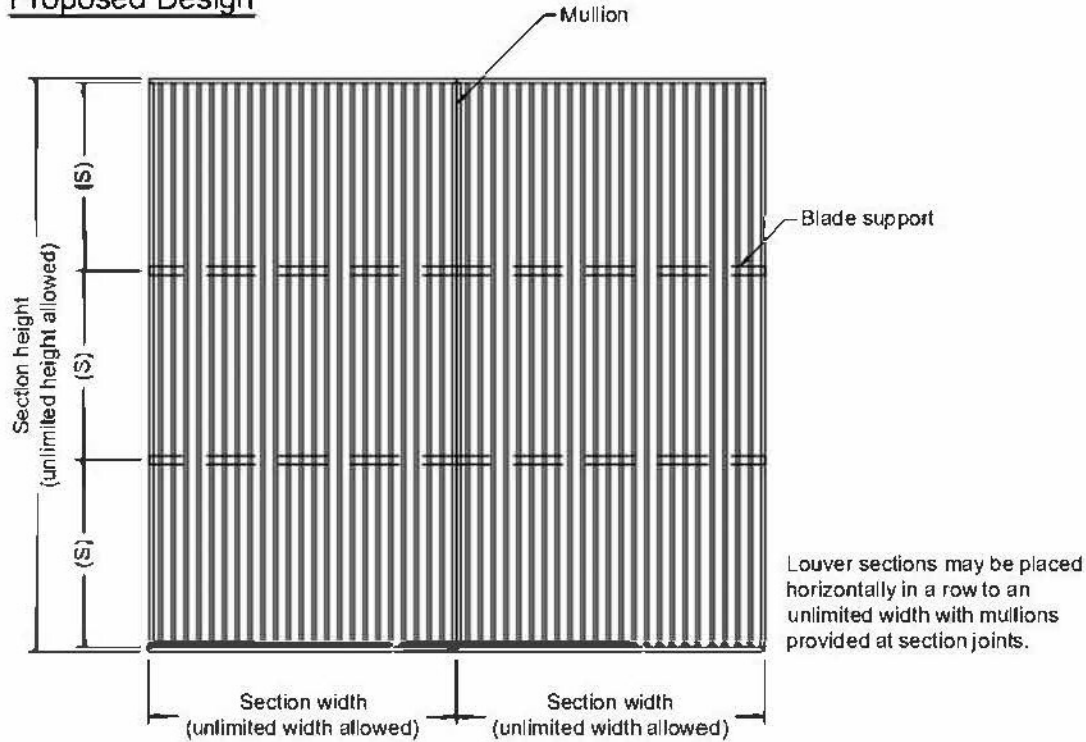
1. Qualification of blade lengths smaller than the test specimen blade length requires an additional test. See Section 4.1.1.
2. Two sections shown for qualification of one mullion type. Three or more sections may be tested to allow qualification of multiple mullion types with one test specimen. For example, when qualifying an architectural, recessed, and visible mullion types with a single test specimen.

Figure A.5 — Example of Multi-Section, Horizontal Blade Louver with Horizontal Mullion Qualification

Test Specimen



Proposed Design



1. Qualification of blade lengths smaller than the test specimen blade length requires an additional test. See Section 5.1.1.
2. Two sections shown for qualification of one mullion type. Three or more sections may be tested to allow qualification of multiple mullion types with one test specimen. For example, when qualifying an architectural, recessed, and visible mullion types with a single test specimen.

Figure A.6 — Example of Multi-Section, Vertical Blade Louver with Vertical Mullion Qualification

Annex B

Follow-Up Service (Informative)

A building code or other specifications may require an ANSI/AMCA Standard 540 louver to be listed/labeled and/or comply with a third-party follow-up service for periodic product inspection. This requirement may be satisfied by participating in AMCA Publication 512, *AMCA Listing Label Program* or another approved agency's program.

RESOURCES

AMCA Membership Information
<http://www.amca.org/member>

AMCA International Headquarters and Laboratory
www.amca.org

AMCA White Papers
www.amca.org/whitepapers

Searchable CRP Database of AMCA Certified Products
www.amca.org/certified

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