Designation: E 1514 – 98 (Reapproved 2003)

Standard Specification for Structural Standing Seam Steel Roof Panel Systems[1]

This standard is issued under the fixed designation E 1514; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the design, construction, and weatherability of structural standing seam steel roof panel systems. It includes performance requirements for the following elements only: panels, concealed panel clips, panel/clip anchorage, and panel joint sealers.

NOTE 1—These systems are used on both low-slope and steep-slope roof applications. They also are used with or without an underlying deck or sheathing.

1.2 The objective of this specification is to provide for the overall performance of the structural standing seam steel roof panel system as defined in 3.2.6 during its service life in order to provide weather protection, carry the specified design loads, and allow proper access over the roof surface in order to provide for periodic maintenance of equipment by the owner.

1.3 In addition to structural, the specifier shall evaluate other characteristics beyond the scope of this specification that affect the final choice of roof construction. These include, but are not limited to, functional, legal, insurance, and economic considerations. See Appendix X1 for specifier's checklist.

1.4 The specification is not intended to exclude products or systems not covered by the referenced documents.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 The text of this specification contains notes and footnotes that provide explanatory information and are not requirements of this specification.

2. Referenced Documents

2.1 *ASTM Standards:*

A 463/A 463M Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process[2]

A 653/A 653M Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process[2]

A 792/A 792M Specification for Steel Sheet, 55 % Aluminum-Zinc Alloy-Coated by the Hot-Dip Process[2]

A 875/A 875M Specification for Steel Sheet, Zinc-5 % Aluminum Alloy-Coated by the Hot-Dip Process[2]

C 711 Test Method for Low-Temperature Flexibility and Tenacity of One-Part, Elastomeric, Solvent-Release Type Sealants[2]

C 765 Test Method for Low-Temperature Flexibility of Preformed Tape Sealants[2]

C 879 Test Method for Release Papers Used with Preformed Tape Sealants[2]

D 1667 Specification for Flexible Cellular Materials—Vinyl Chloride Polymers and Copolymers (Closed-Cell Form)[2]

D 3310 Test Method for Determining Corrosivity of Adhesive Metals[2]

E 631 Terminology of Building Constructions[2]

E 1592 Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference[2]

E 1646 Test Method for Water Penetration of Exterior Metal Roof Panel Systems by Uniform Static Air Pressure Difference[2]

E 1680 Test Method for Rate of Air Leakage Through Exterior Metal Roof Panel Systems[2]

G 21 Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi[2]

2.2 *Underwriters Laboratories Standard:*

580 Standard for Safety, Tests for Uplift Resistance of Roof Assemblies[3]

2.3 *Factory Mutual Research Corporation Standard:*

Approval Standard Class I Panel Roofs Class No. 4471[4]

2.4 *AISI Document:*

Cold-Formed Steel Design Manual, Latest Edition[5]

[1] This specification is under the jurisdiction of ASTM Committee E06 on Performance of Building Constructions and is the direct responsibility of Subcommittee E06.57 on Performance of Metal Roof Systems.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062-2096.

[4] Available from Factory Mutual Research Corporation, 1151 Boston Providence Turnpike, Norwood, MA 02062.

[5] Available from American Iron and Steel Institute (AISI), 1101 17th St., NW, Suite 1300, Washington, DC 20036.

2.5 *MBMA Document:*

MBMA Low Rise Building Systems Manual, Latest Edition[6]

2.6 *ASHRAE Document:*

1997 ASHRAE Handbook, Fundamentals[7]

3. Terminology

3.1 *Definitions:*

3.1.1 Refer to the latest edition of *MBMA Low Rise Building Systems Manual* and Terminology E 631 for definitions of terms used in this specification.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 *construction loads, n*—those loads encountered during the erection of the roof system only.

3.2.2 *fixing line, n*—a line or adjacent lines of fixed points.

3.2.3 *maintenance loads, n*—loads including, but not limited to, personnel, equipment, and materials required to maintain functionality of the building.

3.2.4 *oil canning, n*—a waviness that occurs in flat areas of metal.

3.2.5 *sealer, n*—any material that is used to seal cracks, joints, or laps.

3.2.6 *structural standing seam steel roof panel system, n*—a steel roof system designed to resist positive and negative loads applied normal to the panel surface without the benefit of a supporting deck or sheathing.

3.2.7 *thermal movement, n*—the reaction of the roof system in response to changes in the panel temperature.

4. Performance Requirements

4.1 *Design*—The roof system shall be designed for specified design loads and thermal effects.

4.1.1 Minimum design loads shall be determined by the governing code or the design professional.

4.1.2 The finished roof system shall be capable of sustaining a minimum 200-lb (0.9-kN) concentrated load on any 12-in. by 12-in. (300-mm by 300-mm) area of finished roof without causing seam separation, permanent panel buckling, or loss of weathertightness.

4.1.3 Thermal movement shall be provided for in accordance with Sections 7 and 8. Temperature differentials for many localities are found in documents referenced in 2.5, 2.6, and Footnote 13.[8]

4.1.4 The standing seam roof system clips do not always provide full lateral support to secondary structural members. The degree of lateral support provided to the secondary structural members by the panel system shall be determined by an appropriate test, or in the absence of such test, the panel must be assumed to provide no lateral support.

NOTE 2—The Base Test Method for Purlins Supporting a Standing Seam Roof System in the AISI Cold-Formed Steel Design Manual is used to evaluate lateral support when the secondary structural is cold-formed Zee or Cee purlins.

4.2 *Protection of Incompatible Materials*—Components constructed of incompatible materials shall not be placed together without an effective separating material.

4.3 *Oil Canning*—Oil canning is an inherent characteristic of products covered by this specification, particularly those with broad, flat areas. It is the result of several factors that include, but are not limited to, induced stresses in the base material, fabrication methods, and installation and thermal forces. While oil canning is an aesthetic issue, structural integrity is not normally affected. Oil canning is not grounds for panel rejection, unless it does not meet prior standards established by the specifier.

5. Structural Integrity

5.1 *Panel System Design*:

5.1.1 Structural panels shall be designed in accordance with AISI Specification for the Design of Cold-Formed Steel Structural Members—and in accordance with sound engineering methods and practices.

5.1.2 Deflection and serviceability shall be accounted for.[9] The deflection shall be limited so as to allow the roof to perform as designed. The substrate deflection shall not cause strains to the panels that affect the serviceability of the system.

5.2 *Panel System Testing*:

5.2.1 *Static (Positive or Negative Load Capacity)*—When the panel system does not comply with the requirements for using the design procedures of the AISI Specification, testing shall be performed to determine the roof's load capacity.

5.2.2 *Uplift Index*—When required by the specifier, the roof system shall be tested in accordance with the requirements of Section 5.3 of Factory Mutual Research Corporation Approval Standard 4471, or Underwriters Laboratories U.L. 580 or Test Method E 1592 or other applicable tests (see Appendix X2).

6. Panel Material

6.1 Panel material shall be a hot dip metallic coated product in accordance with one of the commonly used materials listed in 6.1.1-6.1.4.

6.1.1 Aluminum coated sheet steel produced to the requirements of Specification A 463/A 463M. Coating designation T265.

6.1.2 Aluminum-zinc alloy coated sheet steel produced to the requirements of Specification A 792/A 792M. Coating designation AZ-55. When an organic finish coating is used (as described in 6.2), coating designation of AZ-50 shall be permitted.

6.1.3 Zinc coated sheet steel produced to the requirements of Specification A 653/A 653M. Coating designation G90.

6.1.4 Zinc-5 % aluminum alloy metallic-coated sheet steel produced to the requirements of Specification A 875/A 875M. Coating designation GF90.

6.2 In addition to the foregoing material specifications, the specifier has the option to require organic finish coatings.

6.3 This specification does not preclude the use of other coating standards governing the same materials, as long as

[6] Available from Metal Building Manufacturers Association, 1300 Sumner Avenue, Cleveland, OH 44115.

[7] Available from American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.

[8] 1981 *B Climatography of US No. 81*, National Climatic Data Center.

[9] Fisher, James M., and West, Michael A. "Serviceability Design Considerations for Low Rise Buildings," AISC Design Guide No. 3.

equivalency is established. The designer shall determine the suitability of material for the application.[10]

6.4 Steel grade and base metal thickness shall be as required to resist specified design loads.

7. Panel Clips

7.1 Connections of panels to structural members shall be made with concealed panel clips compatible with the panel design.

7.2 Provisions for the thermal movement between the panel and the structure to which it is attached shall be accomplished by the use of concealed panel clips allowing such movement, except as provided in 7.3.

7.3 When the building geometry and the rotational flexibility of the supporting member permit, it is permissible to resolve thermal movement through controlled rotation of the intermediate structural members rather than movement within the clip.

7.4 Where insulation is applied between the panels and supporting structure, the panel clips shall be designed to be compatible with the thickness and compressibility of the insulation. If thermal spacers are required for thermal performance, the clips must be compatible with the thermal spacer to reduce secondary stresses due to walking.

8. Panel and Clip Anchorage

8.1 A fixing line is required to anchor roof panels in order to maintain end alignment and to resist in-plane gravity and thermal force components.

8.2 Fasteners that penetrate the roof surface are permitted only at panel endlaps, penetrations, fixing lines, rib reinforcements, and at roof termination lines. Details at these locations shall allow for the expected thermal movement.

8.3 Nails shall not be used where subject to withdrawal loads.

9. Weather Tightness

9.1 Panel-to-panel sidelap connections and endlaps shall be weathertight.

9.2 Panels of maximum practical lengths shall be used to minimize endlaps.

9.3 *Sealers*:

9.3.1 *Sidelap Sealer*—When climate, roof slope, and roof system design warrant, the standing seam sidelap shall have a sealer. When the sealer is factory applied, it shall remain in place and be protected during transit. In some cases, the panel geometry will provide the required protection. All sealers shall remain in place during panel installation and be protected during storage and installation from any contamination or abrasion that unduly affects service.

NOTE 3—When the slope of the roof is steep, or when the roof system is in a geographic area with little rainfall or snowfall, a sidelap or endlap sealer may not necessarily be required.

9.3.1.1 The sealer shall be of sufficient size and shape to fill the maximum void to be sealed and to assure compression after engagement. The minimum compression shall be 30 % by volume or the adhesion plus webbing characteristics shall be as required to maintain watertightness. An appropriate test shall be used to demonstrate the roof panel system's resistance to ponded water. The sealer shall remain flexible between 0 and 140°F (−17.8 and 60°C) to allow engagement, and shall show no signs of cracking when tested in accordance with Test Method C 765 (wrapped 180° over a 1 in. (2.54 cm) diameter mandrel after 4 h at −0°F (−17.8°C)). The sealer shall not be exposed after assembly.

9.3.1.2 The sealer shall be sufficiently resilient to maintain the seal after movement of joints due to fluctuation in external load, or expansion and contraction, or combination thereof. The maximum set when tested in accordance with Specification D 1667 shall be 5 % if compression alone is required to maintain the seal. The sealer shall be capable of maintaining the above level of watertightness after exposure to the service temperature range, –40 to 200°F (−40 to 93.3°C) unless local or project conditions justify that the specifier impose a different range. This watertightness shall be independent of the temperature at the time of panel installation.

9.3.1.3 The sealer shall be non-corrosive and non-staining to adjacent materials and shall exhibit these characteristics after testing in accordance with Test Method D 3310 including water and with elevated temperature exposure for 21 days at 160°F (71°C); the rating shall not exceed "2." The sealer shall be fungus resistant and exhibit this property after testing in accordance with Practice G 21; the rating shall not exceed "1." In meat and poultry processing facilities or other areas requiring USDA inspection, the sealer shall be chemically acceptable to USDA, and shall be requested by the specifier. When FDA compliance is required, appropriate FDA regulations shall be included by the specifier.

9.3.1.4 If the seam design utilizes sealant, and the location of a clip component interrupts the sealant, the design shall not rely on differential movement between the panel seam and the clip component.

9.3.1.5 If the sidelap sealer is interrupted by the installation of a sidelap clip, and if required by the panel system design, the seal shall be completed around the clip. The performance characteristics of the supplemental sealer shall be equal to the primary sidelap sealer. Both sealers' aging characteristics shall sustain the above performance during the design service life of the roof.

9.3.2 *Endlap Sealer*—The panel endlap shall be sealed with either a field applied tape or cartridge-type sealer or a combination of both. The endlap sealer shall be equal in performance to the sidelap sealer. Minimal sealer exposure shall be allowed after installation.

9.3.2.1 The following requirements shall additionally apply. Cartridge sealers shall remain fluid and sealing tapes shall release cleanly from any backing paper at temperatures ranging from 0 to 140°F (−17.8 to 60°C). Backing paper shall release cleanly after exposure to moisture and when tested in accordance with Method C 879 using Procedure, Alternative A. Tape sealers shall show no cracks or loss of adhesion after exposure in accordance with Test Method C 765 with the modified ¼ in. (0.64 cm) mandrel requirement (bent 180° over a ¼ in. (0.64

[10] Equivalency shall be evaluated on the basis of minimum coating (thickness) of same material, according to the appropriate ASTM Specification.

cm) mandrel). Cartridge-type sealers shall be tested in accordance with Test Method C 711. When required, both Test Method C 765 and Test Method C 711 shall be modified using a cold temperature preparation at 0°F (−17.8°C). When adhesion is required to achieve a seal, sealers shall adhere to panel surfaces, and remain tacky and toolable for twelve minutes after initial application over the same temperature range. Moderate foot traffic during or after installation shall not pump the sealer out of the joint. Sealers shall perform on panels that are lightly coated with lubricants or airborne contaminants unless the Sealer Manufacturer requires and the specifier accepts a panel cleaning procedure. Sealers and tapes must be compatible when used in tandem; both must be compatible with contiguous materials. The endlap sealer must maintain a water tight seal when tested in a lapped joint and in accordance with the ponding procedure of 9.3.1.

9.3.3 *Exposed Exterior Sealers*—Follow or exceed the panel manufacturer's recommendations concerning type and installation and maintenance procedures for exposed sealers at flashings, penetrations and perimeter details. The sealer installation characteristics shall be equal to those of endlap cartridge sealers, for example, compatibility, service temperature range, adhesion, and so forth. The exposed sealer shall also develop a surface skin to minimize contaminant pick up. The sealer shall be flexible and shall maintain performance during and after movement within the system caused by either external loads or thermal response. Exposed sealers shall be substantially unaffected by exposure to sunlight, ultraviolet radiation, ice, snow, rain and the temperature range, –40 to 200°F (−40 to 93.3°C) unless local or project conditions justify that the specifier name a different temperature range. They shall maintain their adhesive, cohesive and weathertightness properties throughout the design service life of a properly maintained system. The detail weathertightness shall be equal to that of the adjacent system.

10. Installation

10.1 Standing seam roof panel systems shall be installed in accordance with the system design requirements.

11. Keywords

11.1 anchorage; clips; coatings; construction; deflection; endlaps; environmental; exposed; exposure; fasteners; flashings; galvanized; installation; joints; loading; loads; low-sloped; metal; oil canning; panels; penetrations; ponding; roof; sealer; seismic; service life; sidelap; slope; snow; standing seam; steel; structural; superimposed; tapes; thermal; uplift; water; weathertightness

APPENDIXES

(Nonmandatory Information)

X1. ADDITIONAL ROOF PERFORMANCE CONSIDERATIONS

X1.1 Scope

X1.1.1 This appendix, although it may not be all inclusive, provides a quick checklist of additional design considerations to assist the specifier in the use of this specification.

X1.2 Design Considerations

X1.2.1 Prescribe the anticipated service life to the system.

X1.2.2 Specify the design loads: Live, snow, rain, ice, seismic, construction, and maintenance. To avoid various interpretations, it is preferred that design loads be specified rather than the referencing of codes or standards. It is the responsibility of the specifier to notify the owner and the responsibility of the owner's maintenance personnel to not exceed the specified maintenance loads.

X1.2.3 Provide any unusual temperature extremes or ranges that are unique to a project. (Whether the temperatures occur throughout the roof field or localized, for example, hot stacks.)

X1.2.4 Notify the engineer of record that additional wind bracing might be required for the primary structure and that additional bridging may be required at the purlins.

X1.2.5 Consider "oil canning" as the specification is prepared.

X1.2.6 Establish the allowable deflection at design load.

NOTE X1.1—Deflection will be relative to the adjacent purlins.

X1.2.7 Specify the required wind uplift test procedure (if any is required). See Appendix X2 for commentary.

X1.2.8 Provide unusual local environmental or atmospheric conditions (interior, exterior, or both) that can affect the choice of base materials, accessories, and organic coatings, for example, marine environment, high SO_2, or acidic conditions, localized settlement from exhaust stacks, high humidity inside building, and so forth.

X1.2.9 Provide a description of the building end use.

X1.2.10 Specify the acceptable level of air infiltration and water penetration or default to the requirements of 9.3 *Sealers*. (See Test Methods E 1646 and E 1680 for water penetration and air leakage test methods.)

X1.2.11 Consider illumination requirements. Provide location and type of penetrations and of roof mounted equipment.

X1.2.12 Provide fire resistance considerations.

X1.2.13 Provide interface details with other parts of the structure.

X1.2.14 Provide details for the configuration and flashing of all penetrations through the roof surface.

X1.2.15 In certain applications of uninsulated construction, it is necessary to protect panel underside from abrasion at the purlin or secondary members which may arise from wind flutter or differential movement between panel and support member. This can be accomplished by the use of insulation, thermal spacer or other "buffer" material.

X1.2.16 Relative movement of separate components that make up a panel system may occur if factors, such as snow or

thermal movement, are not considered. Secure components such that their direction of movement is considered.

X1.2.17 Provide a means for mitigation of condensation, which could adversely affect the roof system, the structure, or its contents.

X2. UPLIFT TESTS

X2.1 *Commentary*

X2.1.1 Wind represents a complex loading which cannot be duplicated in a laboratory by uniform static pressure. Real wind pressures vary in magnitude, as well as in duration. Uniform static pressure test methods with edge conditions representative of actual field conditions, such as Test Method E 1592, generally will yield conservative results when compared with system performance under actual wind loadings. With current code design pressures, uniform pressure tests may yield conservative results. Procedures have not yet been developed to account for the load sharing that can occur in multiple layer roof construction.