results of UL 580 tests cannot be directly translated into the allowable wind uplift pressures, despite some roofing salespeople's claims to the contrary. A UL 580 90 Wind Uplift Classification does not mean the roofing can safely support a 90 lb/ft^2 uplift, although the specimen must resist a combined 105 lb/ft^2 upward load for 5 min to qualify. Essentially, the test results can only be used for "indexing"—comparing the tested panel with other similar products tested the same way and under a stringent set of conditions.

6.10.2 ASTM Testing Procedures

Once the serious limitations of the UL 580 test became understood, many architects and construction specifiers began to seek alternative testing methods. One such procedure, called ASTM E 330 Modified, has become quite popular. The original ASTM E 330 test[36] had been developed for curtain walls, not roofs. Walls and roofs behave differently under wind loading, and the procedure suitable for a rather stiff wall assembly is not readily transferable to flexible metal roofing. Despite its widespread use, the "modified" test procedure is not approved by ASTM for testing metal roofs.

Recognizing the need to develop a proper standard for testing metal roofs, ASTM formed its Subcommittee E06.21.04 to sort out the complexities of the issue. The subcommittee's brainchild, ASTM E 1592, Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference, covers both metal panels and their anchors. It essentially retains the basic approach of the E 330 test method, slightly changing it to allow for the roofing's flexibility.

The specimen size is 5 panels wide (a total of 10 ft) by 25 ft—much larger than in UL 580. Intermediate purlin supports can be placed at variable intervals, and the roofing is continuous over several spans. Panel clips are installed at each line of supports including the panel ends. No other fasteners are provided at the ends and edges, so the panels are free to move under load. The new test specifies loading to be applied in a manner that facilitates detection of slowly developing failures such as seam separations.[37] Instead of being a pass-fail test, ASTM E 1592 provides a standardized procedure to evaluate or confirm structural performance of roofs under uniform static loading. The test runs to failure and therefore allows the ultimate uplift load capacity of the roofing to be determined and tabulated. The procedure complies with the AISI Manual's testing methodology.

It took the subcommittee over 5 years to overcome the initial deadlock[38] and reach a consensus. Once published, however, the document was quickly endorsed by a major industry group, Metal Roofing Systems Association (MRSA), that was formed in January 1994. MRSA has voted to recommend both the ASTM E 1592 and UL 580 as the preferred test methods for standing-seam roofing[39] and produced a technical bulletin explaining the standards to the specifiers. MRSA recognizes the fact that through-fastened roofing behaves differently from standing-seam roofing under wind loading and in fact can be rationally analyzed for uplift, unlike standing-seam roofing. Accordingly, the Association does not feel that the ASTM E 1592 test is required for through-fastened roofing,[40] a reasonable argument supported by MBMA and MCA.

6.10.3 FM Global Standard 4471

FM Standard 4471 contains another widely known test for wind uplift. As a rule, all metal buildings insured by a member company of FM Global (formerly Factory Mutual Systems) must have their roofs compliant with FM Standard 4471, "Approval Standard for Class 1 Panel Roofs." While FM 4471 specifies the design and construction requirements for Class 1 metal and plastic roof panels, a related standard, FM 4470 is used for flexible roof coverings, such as single-ply membranes and built-up roofs. In addition to wind uplift resistance, FM 4471 evaluates nonstructural criteria such as resistance to fire, foot traffic, and leakage.

The size of the roofing assembly used for wind uplift testing is 12 × 24 ft. The assembly must include the connecting fasteners and clips that are used in service. After the roofing edges are sealed and clamped at the perimeter, the panels are subjected to increasing wind pressure from the underside until the assembly either fails or is able to sustain a certain pressure for 1 min.

This maximum uplift pressure forms the basis for the panel rating, such as 1-60, 1-90, 1-120, 1-150, or 1-180. For example, a panel that can sustain a wind uplift pressure of 90 psf for 1 min is assigned FM rating of 1-90 (the number 1 signifies Class 1 roof panels). Using a safety factor of 2 yields a maximum allowable design load of 45 psf.[41] Like UL 580, FM 4471 does not consider wind gusts and is a "static" test.

6.10.4 U.S. Corps of Engineers Testing Procedures

Concerned that the available testing procedures listed above fail to accurately measure wind uplift resistance of standing-seam roofing, the Corps has created (and then largely abandoned) its own testing methodology. The older editions of its Guide Specification for Military Construction Section 07416 prescribed a procedure for the testing believed to better reflect the effects of the actual field conditions. For this test, Standard Test Method for Structural Performance of SSMRS by Uniform Static Air Pressure Difference, the edge details must correspond to the actual field construction; the perimeter clamping is out. The test must be performed under the supervision of an independent professional engineer using the procedures approved by the Corps.

Some consider the Corps-developed procedure a cross between the methods of "modified" ASTM E 330 and ASTM E 1592, plus the new supervision requirements. It attracts the same criticisms for being "static"—not accounting for nonuniform roof pressure distribution—requiring only a small number of loading cycles, and not being designed to determine an allowable load capacity of the roof.[35] Despite being one of the more realistic tests for metal roofs, the Corps' procedure has been de-emphasized in favor of ASTM E 1592. The roof systems previously tested and approved under the Corps' testing method may still be acceptable.

6.10.5 Which Test to Specify and Why

Why test metal roofing at all, instead of, say, full-scale testing of pre-engineered buildings? The answer is, structural behavior of primary building frames subjected to wind uplift can be reasonably predicted by calculations, but that of standing-seam metal roofing cannot be.

Metal panels deflect and distort so much under uplift loading that the analysis based on a flat section is as relevant to their actual behavior as the beam theory is to arches. Moreover, many panel failures occur because of unlocking of the panel sidelaps at the clip locations and excessive bending stresses introduced into the "hook" portion of the clips.[35]

So, if the rational design is not available and testing procedures are imperfect, what is a specifier to do? A sensible course of action for critical applications might be to require the standing-seam roofing to be tested in accordance with ASTM E1592. It is also wise to carefully investigate any alternative testing methods proposed by the supplier, since some manufacturers already conduct dynamic testing of their products, arguably superior to the static ASTM procedure. The manufacturer's track record should provide some assurance as well.

Meanwhile, a quest for the perfect test continues. Among other studies, MBMA and AISI are sponsoring research conducted at Mississippi State University, Starkville. The new 32- by 14-ft air pressure chamber at that facility can simulate "real-world" wind gusts by electromagnetically providing a nonuniform pressure distribution that can be changed almost instantaneously. We hope that a better understanding of the ways the real wind acts on the roofs will lead to more reliable testing methods for standing-seam roofing.

6.11 SOME TIPS ON ROOFING SELECTION AND CONSTRUCTION

Metal roofing can provide long and largely maintenance-free service life if designed and installed correctly. The designer's contribution is to select the proper roofing product and details for the building.