Roofing Research and Standards Development: 3rd VOLUME

Wallace/Rossiter, editors

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Thomas J. Wallace and Walter J. Rossiter, Jr., Editors

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The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution to time and effort on behalf of ASTM.

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Foreword

This publication, *Roofing Research and Standards Development: 3rd Volume,* contains papers presented at the symposium of the same name, held in Montreal, Canada on 19 June 1994. The symposium was sponsored by ASTM Committee D-8 on Roofing, Waterproofing, and Bituminous Materials. Thomas J. Wallace of the Naval Facilities Engineering Command in Philadelphia, PA and Walter J. Rossiter, Jr. of the National Institute of Standards and Technology (NIST) in Gaithersburg, MD presided as symposium chairmen and are editors of the resulting publication.

Overview

The revolution that has occurred in the roofing industry around the world over the last 15 years is well known to all. Many roof systems that incorporate elastomeric, thermoplastic, and polymer-modified bituminous membranes were unheard of in the early 70s, but are commonly used today. Improvements in the chemistry and production technology have enhanced the performance of these materials and made them economically competitive for roofing. Further, the use of glass- and polyester-based fabrics has essentially replaced the traditional reinforcements for built-up roofing membranes. The industry has also seen increased use of sprayed-in-place polyurethane foam systems and the application of liquid materials for protection and maintenance. The arrival of many of the new systems has lead to innovative methods of application such as ballasting and mechanical attachment.

The revolution has been beneficial to the industry. Many of the new systems have performed well, and the variety of systems available provides consumers, including building owners, design architects, and roofing contractors with a broad choice from which a particular system may be selected for a given application. Nevertheless, not all of the new systems introduced to the market over the last 15 years have been successful. In fact, any roofing technologist can provide examples of systems that were procurable by consumers a few years ago, but are not available today. A challenge to the members of the roofing community is to provide standards that assist consumers in selecting and using systems that provide long-term satisfaction while addressing current environmental needs. Demands to improve the quality of our environment have meant that some materials and systems, considered environmentally acceptable 15 years or so ago, are not necessarily acceptable today. Consequently, the roofing industry is tasked to replace unacceptable products with a new generation of alternative materials and systems that are not detrimental to the environment.

This challenge has placed strong pressure on ASTM Committee D-8 on Roofing, Waterproofing, and Bituminous Materials to develop standards to assist in the selection, use, application, and maintenance of these systems. Committee D-8 has responded well. Many task groups are working diligently to maintain and upgrade standards previously issued and to develop the new standards that are still urgently needed. These standards include not only specifications for membrane materials, but also test methods for their characterization and practices for their application and evaluation.

The proceedings of three symposia describing the changes that have occurred and the needs for research to support development of standards have been published since the early 1980s: *Single-Ply Roofing Technology, ASTM STP 790,* 1982, edited by W. H. Gumpertz; *Roofing Research and Standards Development, ASTM STP 959,* 1986, edited by R. A. Critchell; and *Roofing Research and Standards Development: 2nd Volume, ASTM STP 1088,* 1990, edited by T. J. Wallace and W. J. Rossiter. But the work of Committee D-8 is far from completed, particularly in the area of providing data and conducting research to support standards development.

The members of D-8 firmly believe in the importance of having a strong technical basis for their Committee's standards. The availability of data can help accelerate the standards development process, because decisions can be made on fact and not opinion. As an example, the consensus of D-8 members is that task groups developing new standard specifications provide data supporting recommended requirements for material properties. Without supporting data, the drafts do not proceed forward.

This symposium was conducted under the auspices of Subcommittee D08.21 on Research Needs for Roofing and Waterproofing. This symposium and the papers described in the proceedings illustrate D-8's commitment to developing standards having strong technical bases, which ultimately contributes to improved roof performance.

As in the past, this publication is dedicated to the members of ASTM Committee D-8 who give unselfishly of their time and energy to improve the performance of roofs. The editors express their sincere thanks and appreciation to those many individuals who participated in the organization and conduct of the symposium. R. A. Alumbaugh, W. C. Cullen, R. L. Fricklas, J. M. Goodwillie, D. F. Jennings, J. F. Lindberg, C. F. Mullen, R. E. Norris, D. E. Richards, G. A. Smith, T. L. Smith, and J. R. Wells were D-8 members of the steering committee. D-8 members H. Hardy Pierce and J. F. King were session chairpersons. Dorothy Savini and Pat Barr, both of ASTM, provided for symposium arrangements. Rita Hippensteel, Therese Pravitz, Shannon Wainwright, Kathy Dernoga, and other ASTM staff members directed the review and publication of the papers. Finally, special thanks are given to the authors and reviewers of the papers without whose efforts the symposium would not have been possible.

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Standards Developments and Test Methods

William C. Cullen[1]

PROBLEMS PROMPT A QUEST FOR HIGH QUALITY STANDARDS

REFERENCE: Cullen, W. C., "**Problems Prompt a Quest for High Quality Standards,**" Roofing Research and Standards Development: 3rd Volume, ASTM STP 1224, Thomas J. Wallace and Walter J. Rossiter, Jr., Eds., American Society for Testing and Materials, Philadelphia, 1994.

ABSTRACT: Roofing problems can be traced to a lack of standards, inadequacies in standards, non-conformance to or non-enforcement of standards. It follows that the occurrence of certain problems can be reduced or eliminated by producing appropriate, quality standards that are adhered to by the specified products. Five case studies are examined that focus on roof performance problems dealing with specific roofing materials described by ASTM standard specifications.

Suggestions are offered for revising specific standards by adding requirements based on available research results. Packaging and labeling requirements as well as precision and bias statements are also discussed.

KEYWORDS: ASTM standards, asphalt, case studies, recommendations, research results, roofing deficiencies, roofing products, shingles and standards.

Roofing performance relies on the quality of design, materials, application and maintenance aspects of the roofing system. Roofing deficiencies may result when the quality of one or more of these factors is lacking. Standards and specifications are used to define and prescribe the quality in these factors.

Roofing problems sometimes can be traced to a lack of standards, inadequacies in standards, non-adherence to or non-enforcement of standards. It follows that some roofing problems can be eliminated by ensuring standards are of good quality and products conform to criteria of the prescribed standards.

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Research and performance experience provide the technical basis for producing high quality standards. The 86 year history of ASTM Committee D-8 attests to the importance of current and reliable technical information in the standard development process.

PURPOSE AND SCOPE

The paper deals exclusively with ASTM standards related to roofing. It reviews five case studies of performance problems resulting in part from mediocre standards. It examines reasons for producing standards of inferior quality.

It contends that ASTM Committee D-8 has the expertise and capability to produce high quality standards commensurate with available technical information and performance experience. However, in many cases, sufficient technical data and information are not available to produce a good standard. In others, where information is available, member expertise and capabilities are not always applied to acquire a standard of satisfactory quality for self-serving reasons of individuals or organizations they represent. In brief, the paper contends that ASTM Committee D-8 needs better quality control in its standards development process for the best standards commensurate with currently available information.

Additional questions are raised why roofing products, manufactured to meet ASTM standards, fail to meet the standards. The hesitation of some producers to include statements of compliance with ASTM standards in labeling products is discussed.

Finally, the paper encourages material suppliers to assure that products meet the standard requirements rather than imply products meet standards, when they do not. It prompts an awareness among buyers to insist the products they purchase conform to the criteria of the referenced standard in all respects.

CONSENSUS STANDARDS

In theory, consensus standards are developed via compromises reached among producers, consumers and general interest members of a standards committee. In practice, this is not always the case. On the surface, it appears that the development of product standards is based more on marketing potential and market competitiveness rather than on the technical quality of available test data and performance information. On the surface, It appears that standards criteria are set at appropriate levels to ensure all marketed products meet the standard. In contrast, the intent of the consensus standard development process is that products should be manufactured to conform to standards rather than standards produced to conform to marketed products.

ASTM advocates that standards criteria be set at levels validated by test data and performance experience. Further, ASTM requires that precision and bias statements be included in test method standards. However, this practice is often overlooked to expedite the publication of a standard. Precision and bias statements are frequently meaningless and even ludicrous. As an example, in the 1993 Annual Book of Standards, the precision and bias statement in ASTM D 3161 Standard Test Method for Wind-Resistance of Asphalt Shingles states, "The precision and bias of this method have not yet been determined." The test method was originally published in 1972. To date, it has taken 22 years to establish a realistic and meaningful statement.

ASTM should either abolish the precision and bias requirement in test method standards or not approve the advancement of test methods to standard without reasonable and useful statements.

In summary, standards criteria must be set at levels commensurate with fairness, research results and performance experience. Criteria must *not* be influenced by commercial pressures placed on or by committee members to compromise the credibility of the ASTM consensus development process.

STANDARDS INADEQUACIES

The case studies that follow exemplify the weakness of certain standards as reflected by performance experienced in the roofing industry. In some cases, they were due to a dearth of technical information. In others, products implied to meet standards, did not meet the standards. In still others, market competitiveness played a key roll.

In the first case, adequate technical data were not available during the original standards development process. Next, the technical community failed to recognize the need to upgrade the standard's criteria as performance information became available. On the positive side, it demonstrates how performance problems prompted committee action to upgrade a standard by eliminating the problem with considerable monetary savings to producers, appliers and consumers.

More recent case studies explain how some current problems could be eliminated or substantially reduced by upgrading existing criteria, adding new requirements and providing products that meet or exceed minimum stated requirements.

Organic Asphalt Shingles

In 1925, ASTM Committee D-8 produced Standard Specification D-225 for Asphalt Shingles (Organic Felt) Surfaced with Mineral Granules, the first ASTM standard defining the requirements for organic based, asphalt shingles. These products were commonly referred to as 210 pound shingles. During the 1950s, a problem surfaced, called clawing,[2] and reached near epidemic proportions. The clawed shingles actually became completely unserviceable after 2 to 4 years. The products of most shingle producers were involved.

The National Bureau of Standards (NBS),[3] with the full cooperation and assistance of shingle producers, launched an extensive field and laboratory investigation to determine causes and suggest solutions. Marshall and Ruegg [1][4] discuss the economic impact of the NBS research and subsequent upgrading of the standard.

On-site inspections, by NBS researchers, revealed the problem was widespread and needed immediate attention. Testing of new and flawed products confirmed that the defective shingles met the requirements of ASTM Standard D-225. The research results indicated that dimensional instability was the mechanism of failure. This resulted from the alternate wetting and drying of the organic reinforcing felt. The porous back coating allowed moisture to penetrate and exit the felt on a cyclic basis. NBS researchers concluded that undersaturation of organic reinforcing felts and insufficient back coating were major contributors to the problem. They recommended increasing the asphalt saturation of the reinforcing felt and applying a heavier asphalt back-coating to provide sufficient protection to prevent moisture intrusion into the felt.

NBS petitioned ASTM and Underwriters Laboratory (UL) seeking an immediate revision of shingle standards, ASTM D-225 and UL 55-B. NBS's research results provided the basis for committee deliberations for upgrading both ASTM and UL standards in 1962 [2]. In essence, requirements for heavier back-coating and additional felt saturation with proportional increases in other shingle components resulted in a nominal 235 pound organic shingle replacing the 210 pound shingle.

A second benefit from upgrading the standard was the change from the thick butt type to the uniform thickness type

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[2]Shingle tabs curled downward.

[3]Now the National Institute for Standards and Technology (NIST).

[4]Figures in brackets refer to references at the end of the paper.

shingle. This alteration eliminated the "burn out" of the thin headlap portion between tabs previously experienced.

All manufacturers responded by producing the 235 pound shingle. The clawing problem as well as other problems was essentially eliminated.

Glass Fiber Reinforced Asphalt Shingles

A more recent case has come to light involving the substandard performance of fiber glass based, asphalt shingles. The Western States Roofing Contractors Association (WSRCA) brought this situation to the industry's attention in 1991 [3]. Complaints on performance problems by their members prompted an association-wide survey. It revealed that many shingle problems occurred as early as six months to 12 years. The predominate failure mode was fracturing (cracking). Seal down deficiencies, granule loss and curling were also reported as problem areas being experienced. The average failure time of the "20 year" shingles was 5 years. Next, the association initiated a testing project.

On separate occasions, shingles representing the products of 12 manufacturers, obtained on the open market, were tested by a commercial laboratory for conformance to ASTM Standard Specification D-3462 for Asphalt Shingles Made from Glass Felt and Surfaced with Mineral Granules. For the most part, the shingles met the requirements of the standard except for the tear strength requirement. Only two samples of the 24 tested met the 1700 grams requirement for tear strength. In fact, the results varied from a low of 762 grams to a maximum of 1802 grams. These results compare with tear strengths of 2200 plus grams measured for organic base shingles which were tested for comparison.

The Midwest Roofing Contractors Association (MRCA) [4], following up on the WSRCA study, sponsored a series of tear strength tests at a commercial laboratory. The objective was to determine if samples of commercial 20-25 year fiberglass and 20 year laminated fiberglass met the 1700 gram tear resistance requirement of Standard ASTM D3462. MRCA reported that 10 of 11 20-25 year fiberglass shingles and 6 of 6 of the 25-30 year laminated fiberglass shingles failed the 1700 gram criterion.

The events suggest several lessons for the roofing and standards communities. First, the consensus standard makers should strive to produce standards that are both adequate and complete and contain requirements that reflect performance. Next, manufacturers should provide products that meet or exceed the minimum requirements of the specified standards. Neither of these conditions came to pass in the asphalt shingle case.

The WSRCA recommended that statements of compliance with stated ASTM standards be prominently displayed on package labels. This is a separate issue that is discussed later in the paper.

These activities prompted shingle manufacturers to start a research program to develop performance tests and criteria for inclusion into ASTM standards.

PVC Roof Membranes

In 1985, ASTM Committee D-8 developed the first single-ply, roof membrane consensus standard D 4434 for Poly(Vinyl Chloride) Sheet Roofing. The requirements of the standard were based on product data that were available at the time.

During the late 1980s, a problem surfaced with non-reinforced PVC membranes. Dupuis [5] identified the problem as a potentially catastrophic membrane failure. He reported that the failure mode involved the spontaneous shattering of PVC membranes in various size pieces which often occurred during cool weather. The problems were isolated to unreinforced PVC membranes.

The first incidence of PVC shattering was reported in NRCA's Project Pinpoint Survey in 1983. A marked increase in the number of reports in 1988 and 1989 was recorded in the pinpoint data base. Since the initial survey information was limited, additional data were needed to verify the magnitude and extent of the problems.

The additional survey of NRCA contractor members, conducted in 1990, reported on 186 problem roofs. It revealed the problem to be wide-spread and involved the products of at least six PVC roof membrane producers. The analysis indicated:

- Non-reinforced PVC roof membranes were involved exclusively.
- Frequency of PVC shatter problems increased in 1987.
- The median age of fractured membranes was 8 years.
- Fractured roofs were largely ballasted.
- Problems occurred during cold weather.
- Problems occurred often instantaneously.
- Problems were often initiated by a person on the roof.
- Entire roof or roof sections were frequently involved.

Two questions arise. Did the fractured materials meet ASTM Standard Specification D-4434? If the answer is yes, could the fracturing have been prevented or reduced if D-4434 standard included stricter performance requirements to prevent this type of failure mode, and if the materials were produced to meet the standard?

Paroli, Smith and Whalen [6] reported on the phenomenon of the shattering of unreinforced PVC roof membranes. The paper provides information on the shattering problem and offers suggestions to avoid the shattering of existing PVC membranes. Paroli presents the results of dynamic mechanical analysis showing property differences between the shattered and normal PVC samples. Further, the authors found that the glass transition temperature, T_g, may be useful in explaining the PVC shattering phenomenon. They suggest such test methods employing thermal analytical techniques should be considered in the revision of ASTM Standard D-4434.

In addition to the glass transition temperature requirement, criteria for heat aging (suggested by Lys [7]), dimensional stability and flexibility would provide a measure of a membranes susceptibility to fracture after aging. Such requirements should be considered for inclusion in the next revision of the ASTM standard.

Coal Tar/Asphalt Glass Felt Built-Up Membranes

For several years, asphalt impregnated glass felts were used as reinforcements in constructing coal tar built-up membranes. Complaints surfaced from several sources about performance deficiencies of these systems. Concern has been raised, rightfully or wrongfully, about compatibility reaction actions when using Types I and III coal-tar pitch as the mopping medium in built-up roof membranes reinforced with asphalt impregnated glass felts. The more frequent complaints are centered around the sinking of the reinforcement into the coal-tar pitch.

Cash [8] describes research centering around the subject and discusses the influence of felt porosity on bitumen migration with coal-tar/glass felt membranes. He maintained, that if felts are too porous, the surfacing aggregate presses the glass felt to the bottom of the membrane, causing performance difficulties. Cash concluded that coal tar should not be used with glass fiber felts until standards for felt porosity are established. He recommended that the ASTM committee consider porosity requirements be incorporated into the revision of the glass reinforcement standard.

In a follow up paper, Cash [9] reports on research that suggests felt porosity may be contributing factors to sinking felts in coal-tar built-up roof membranes. Further, he contends that sinking felts increase the contact area between the coal-tar pitch and the asphalt to result in compatibility reactions.

The NRCA technical staff, motivated by member complaints of the alleged problems, reviewed NRCA's project pinpoint's returns to shed additional light on any unusual performance problems with these systems. Information on coal-tar/asphalt